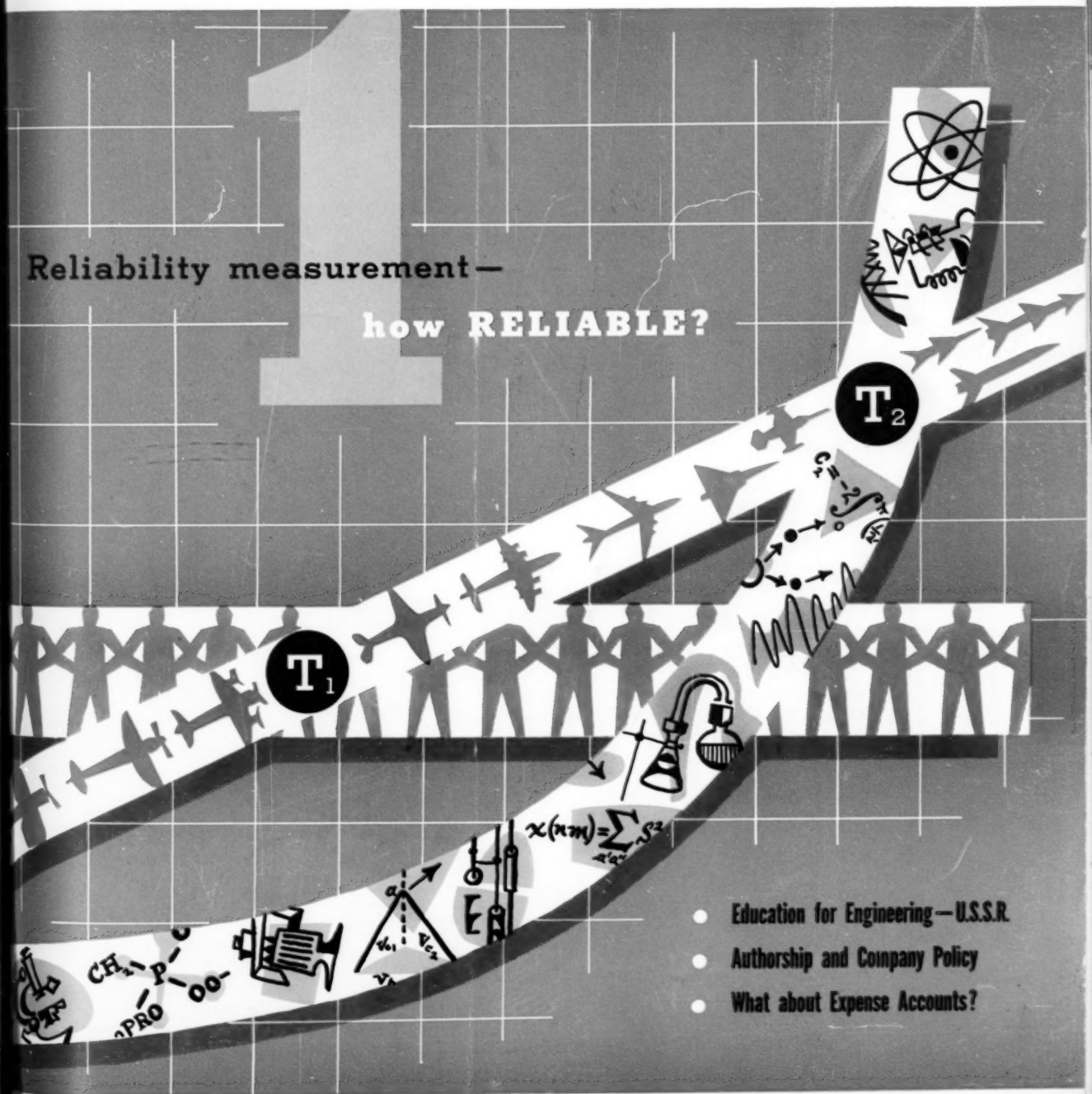
APRIL 1957

Research & Engineering

The Magazine of Technical Management

R/E



- Education for Engineering—U.S.S.R.
- Authorship and Company Policy
- What about Expense Accounts?

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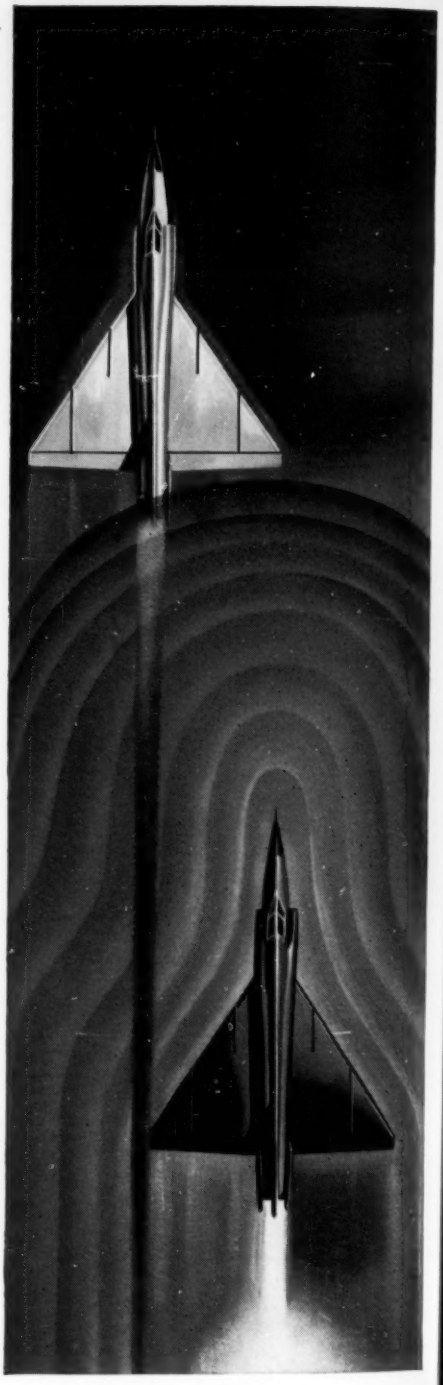

BACK when airframe construction first switched from wood and fabric to light metals — the thin alloy skins were actually sewn together with piano wire. Manufacturing methods had not kept pace with materials development.

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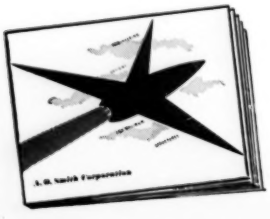

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Research & Engineering

The Magazine of Technical Management

APRIL 1957
VOL. III, No. 4

ON THE COVER: the elements from which Reliability arises. Horizontal line is Human Capability. Intersection at T_1, by Development Capability, was point in time when equipment exceeded human limitations. Later, Development Capability was intersected at T_2 by Research Capability. Here the demands of Research exceeded development resources. And here Reliability is born.

Reliability Measurement—How Reliable? 8
Richard R. Landers

The cult of measurement overlooks many contradictions in present-day reliability assumptions. A top flight reliability engineer points to some of these inconsistencies.

Education for Engineering—U.S.S.R. 12
Lawrence Sandek

Nuclear physicist Edward Teller claims that the American scientific lead has been irretrievably lost, largely because of default in engineering education. R/E examines Russia's methods as revealed by official reports.

Authorship and Company Policy 28
Scott Nicholson

What are companies doing to encourage their scientists and engineers to write for publication? R/E reports the answer in this article.

Saving Printing Dollars 20
Crete Dahl

Your technical literature will be improved in quality and lowered in cost by careful preparation for the printer.

IRE Convention Themes 33
Robert Coleman

Transistors and micro-miniaturization dominated the IRE show at the New York Coliseum.

Technical Management: What about Expense Accounts? 4
A touchy subject is discussed by Dr. Merritt Williamson with an eye to fairness for both engineers and the companies for which they work.

Face to Face: R/E Interviews Christensen of Federal Pacific 16
The research director of a medium-sized electrical products company describes the challenge of keeping abreast of giant competition.

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for MANAGERS of research design and development

Editorial Board: William H. Relyea, Jr. (Publisher and Editorial Director), Scott Nicholson, Lawrence Sandek (Associate Editors), Luis J. A. Villalon, Dr. Merritt A. Williamson (Consulting Editors).

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Letters

Please send all letters to the editor to our editorial offices, 77 South St., Stamford, Conn.

More on Advancement

Washington Grove, Md.

Your February issue carried a letter, "They're Too Healthy!" regarding promotion of engineers from engineering into management.

If a man is truly a first-class engineer, he is unsuited to management. This statement can be backed by thousands of case histories. Your man may be inherently a manager who has learned something of engineering. If this is true, he can be shown how to get into management. But if he is an engineer, he would be well advised to keep away from line management.

As a broker of trained brains, there is hardly a week in which I find no person out of step with his ambitions. Less than one man in four has the prime characteristic for engineering. About thirty-five other characteristics are needed, so the really good engineer is a rare individual. A corporation having such a unique person should keep him in engineering, and at a substantial salary! He can do things for them!

STUART LUMAN SEATON, D.Sc.,
CONSULTING ANALYST

Stamford, Conn.

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WILLIAM A. BARKER
SENIOR ASSOCIATE,
CLARK, CHANNELL, INC.

Information, Please!

Charlottesville, Va.

Since your publication receives notices of unusual testing equipment I wonder if you know of any device for accurately measuring *small* areas. The usual planimeter is not accurate enough for the areas we have in mind, i.e., a reading of say 2 or 3. The problem is of such a nature that an electronic integrator cannot be read.

H. A. MERENESS,
HEAD, MERCHANT'S LAB.,
INSTITUTE OF TEXTILE TECHNOLOGY

Bainbridge, N.Y.

Your excellent article on Solar Furnaces made me wonder if it would be practical to make a plastic paraboloid reflector similar to an inflatable house. An elastic sheet could be mounted as a drum head and the interior partially evacuated to produce a concave surface which would be given a reflective coating. It would probably be necessary to selectively thicken certain zones of the drum head in order to produce a true parabolic curve. I would appreciate comments on such a device.

R. B. DEAN, DEVELOPMENT MGR.,
THE BORDEN CO.,
CHEMICAL DIVISION

Readers' comments are invited.

Fruition

New York, N.Y.

Congratulations to you and to Mr. R. K. Stolz for "Organizing for Effective R/D" in your February issue. This is far and away the best brief exposition on a difficult subject that I have seen yet.

MURRAY BERDICK, PH.D.
COORDINATOR OF RESEARCH
EVANS RESEARCH & DEVELOPMENT CORP.

Rogers, Conn.

We believe that your magazine is doing an excellent job of filling a gap which has existed in periodicals aimed at technical people. We are wondering if you have any plans for including articles on technical report writing in research and engineering in the future.

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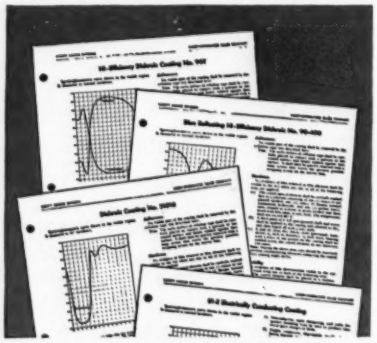

Reference file on vacuum-deposited coatings. Data on reflection, transmission, adherence, hardness, durability, water resistance and other characteristics. Covers these coatings:

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- Beam Splitting Dichroic Filters
- Metallic Electrically Conducting Coatings
- Transparent Electrically Conducting Coatings
- Beam Splitters or Dichroic Mirrors (with transparent electrically conducting coatings)
- Low Reflection Coatings

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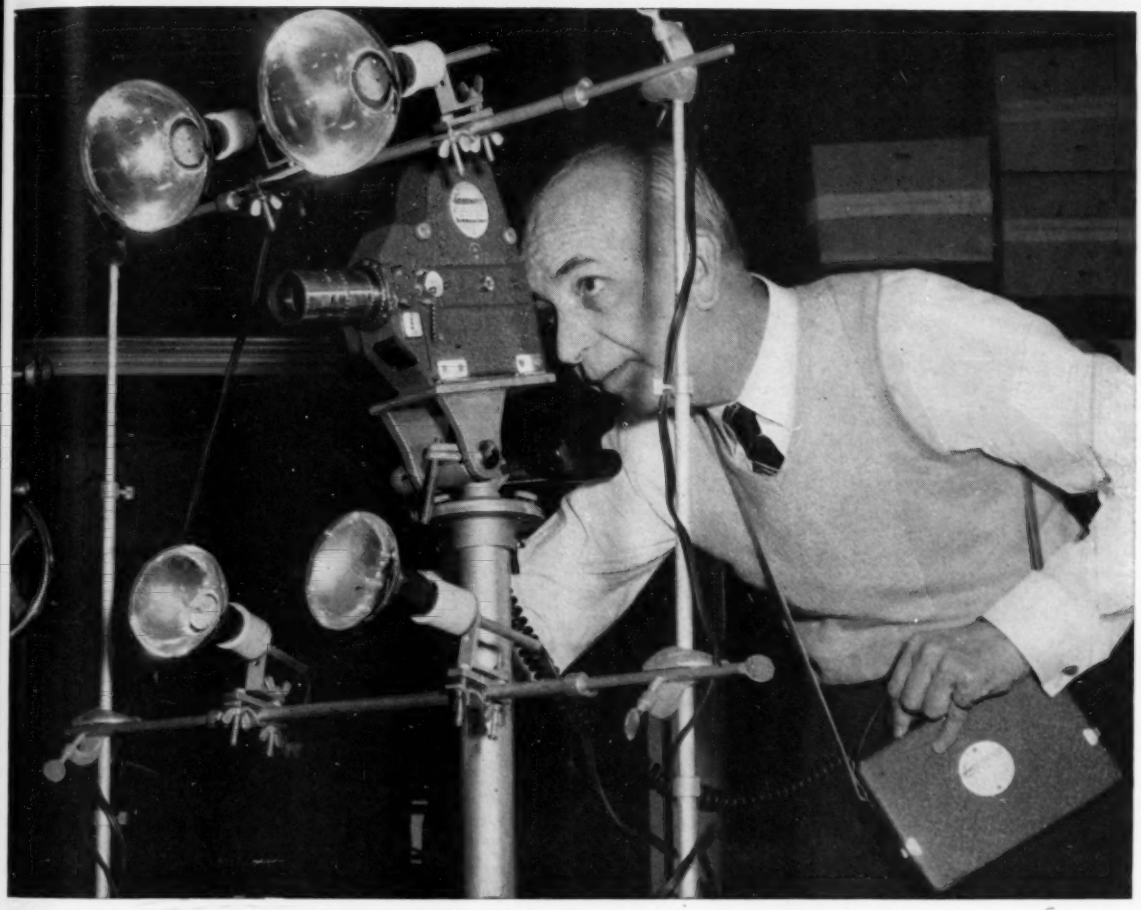

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TECHNICAL MANAGEMENT

Merritt A. Williamson

What about Expense Accounts?

Expense accounts! Here is a subject which may or may not be the bane of a Technical Manager's existence, but is surely a bone of contention with engineers. I am not speaking about expenses for the moving of employees or their temporary living expenses. Such arrangements are usually the result of negotiations between the employee and an officer of the company. But I am speaking of the run-of-the-mill expense accounts for travel and entertainment of "visiting firemen." It is certainly a subject of live importance to the business managers of technical operations wherever they may be in the company's structure. Let's discuss this matter a bit.

What Expenses Are Legitimate?

The reason for an expense account, of course, is to reimburse an employee for expenses he has incurred in the performance of the company's business. This should include payment for activities that contribute to the company's profit or prestige picture, and nothing else. A company cannot afford, however, to be too tight or its personnel will refuse to travel. No employee should be forced to take a loss to benefit the company, nor do I believe that any company really expects them to—although I must say that most expense policies make this necessary.

Companies practices range from no policy at all to very rigid and restrictive policies from which there is no departure. To avoid difficulties and to provide an incentive for economical expenditures, some companies have adopted a straight per-diem allowance.

From the company's point of view, the problem is to determine what the legitimate expenses are. For example, should an employee be reimbursed for a noon lunch on a one-day trip? Many companies reason that the person would have to buy his lunch anyway. I have never felt that this argument was particularly defensible. In the first place, many employees either go home for lunch, bring their own, or eat in the company cafeteria. In these cases a lunch away from home base will cost more than they are used to paying. I realize that the policy of reimbursing for lunches might mean an outlay of thousands of dollars if it were extended to salesmen who plan their routes and who receive allowances and bonuses. Nevertheless, in the case of engineers, who do not make a regular habit of lunching away from home base, I believe some reimbursement might be offered when they are away in the daytime on company business.

Breakfast and dinner, of course, are universally considered legitimate charges on a one-day trip. If a person has to get up and be on his way before breakfast, paying for the breakfast is some compensation for the early start.

When Dinner's on the Company

How much is a reasonable charge for meals? Actual charges vary, of course, with the tastes of the individuals who are traveling. Some people have expensive tastes and they should not be expected to live less comfortably away from home. Others seize the opportunity to live better. Still others, who are very frugal, will turn in an unreasonably low amount. This may be due to fear of criticism as well as frugality. When it occurs, the manager, in my opinion, should investigate. It does not pay to have a company branded as cheap because one of its key men will order only a lettuce sandwich when other company representatives at the same table are having steak.

Should a drink before dinner be included in the cost of a meal? Most companies recognize the facts of life and include it. Should a cigar after dinner be included? Some say yes, others no. Being a cigar smoker and enjoying one after a meal, I think it quite reasonable.

The matter of a hotel is less controversial except perhaps the question of whether one needs to frequent the most expensive places. This depends on the company philosophy. Some companies insist that their representatives stay at only the best hotels. Charges are verified, of course, by the bill submitted with the expenses which proves that the person did actually incur the expense.

(Continued on page 6)

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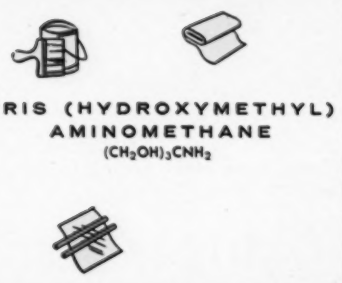

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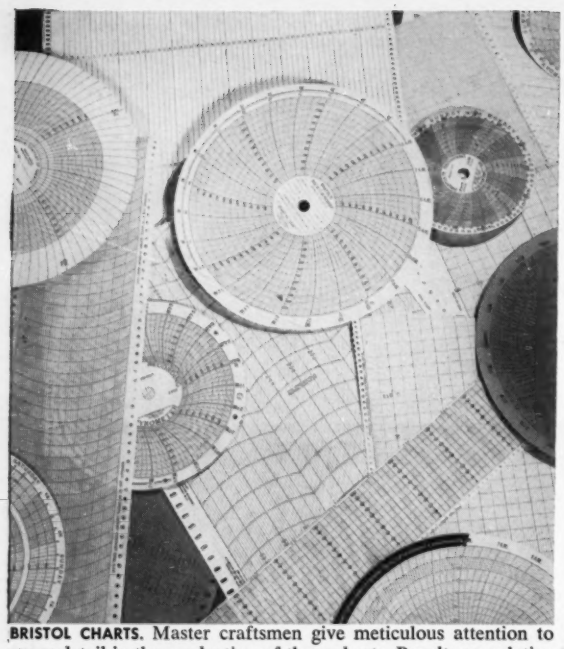

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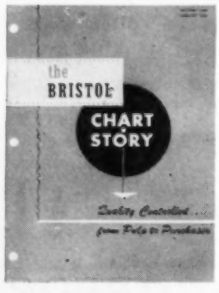

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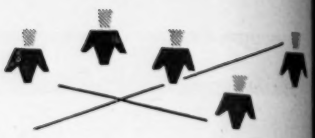

TECHNICAL MANAGEMENT *(Cont. from p. 4)*

Taxis are certainly legitimate as are telephone calls and telegrams. Here the traveler is supposed to exercise reasonable economy by not making unnecessary trips by cab or unnecessary telephone calls. Transportation costs also are hardly questionable, since they can always be verified and pullman and airline receipts can always be attached.

Theater and Night Clubs

Entertainment, however, is quite another matter. What is legitimate entertainment? Here, I think a very pertinent factor is the position of the individual in the organization. To have rigid rules that apply regardless of position is a legitimate gripe as far as I am concerned. It is hard to see where the company could profit by a large entertainment expense incurred by a junior engineer on a trip, but it may be quite in order. When this occurs, I think a note of explanation should be attached. A division or department head should certainly be permitted modest entertainment entries without specifying the exact details. If he is not to be trusted, then he shouldn't be in that position. Any question about the integrity of a man is always a delicate point.

A Handy Guide

Some people who travel for their companies count the money they have when they leave and subtract from it the money remaining when they return and charge the difference to the company. This is sound if there has been no great expense of a personal character.

Someone has to ride herd on expenses and this usually falls to the lot of the business manager or controller. There are established norms to make his life easier and I feel that he is quite within his rights to challenge any excess beyond these norms. I think these norms should be known; and persons should be directed to stay within the limits set or else explain the departures. A person who can decide to take a trip without specific approval should be able to charge his expense without too much question. I am a believer in the formula that if a manager is satisfied that an expense account of one of his men is reasonable, the business office should pay it without question. If the people in the business office feel that a question is in order, they should contact the person who approved it—not refuse to pay the engineer. The best way to insure the workability of this system is for each division to have a travel budget. Then the manager has to take a personal interest in what goes on and doesn't shove it on to the business office.

This Month's Case Problem

To question a man about his expenses is delicate. A question almost implies a reflection on his integrity. What would you do under the following circumstance? Let us hear from you.

You, as Research Manager, send a junior engineer to

(Continued on page 22)

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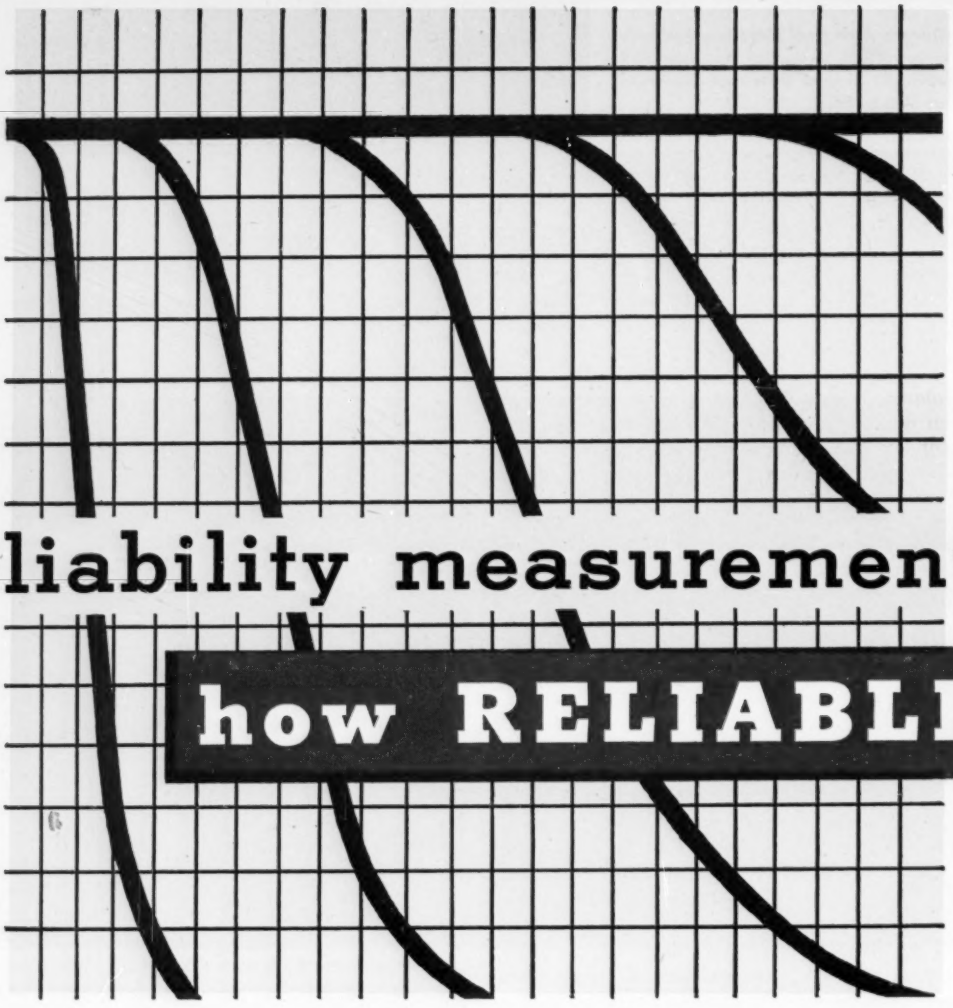

Reliability measurement—how RELIABLE?

Richard R. Landers

How much of the elaborate paraphernalia of Reliability is superfluous? Are the formulae and measurements just gilt on common sense? Here is a discussion of where we might be going wrong.

WHEN IT COMES TO MEASURING SOMETHING, engineers are inclined to jump in with both feet. The idea that a person is an expert in a subject if he can measure it has dominated the field of reliability and has led many people to develop systems of measurement before they fully understood what was being measured. If all the carloads of existing reliability data were analyzed, I doubt whether the statistics would produce more than a few valid conclusions that engineers couldn't have arrived at through common sense. I don't mean to imply that what has been done to date in reliability measurement isn't important. In the short time that reliability has been an organized effort the best work possible has been accomplished. We have reached the point, however, when a reappraisal of the situation is in order. It is time now to pause and reassess the nature of reliability—its tools and results.

What is reliability?

The generally accepted definition of reliability is: *The probability of a device performing its purpose adequately for the period of time intended under the conditions encountered.**

In the rapid technological advances of recent years it is no secret that the ability of equipments to go reasonable lengths of time without failing leaves much to be desired. Simply stated, all complex machines have a factor of unreliability. It is the function of reliability studies to anticipate the extent of unreliability and to prevent failure. This has resulted in organizations of specialized reliability engineers, who devote their talents to determining the causes of unreliability and to controlling them.

The need for reliability measurement

There are essentially two basic reasons for measuring reliability. The first is to determine if the manufacturer is complying with the terms of the contract as required by the customer. This is done by monitoring the day by day progress. With a quantitative method of measurement, the manufacturer can plot growth curves and realistically determine the point of release for production. Without this method, the best he can do is make a series of compromises based on judgment and past experience. This may result in too early release with consequent extensive field retrofits. Or it may mean a longer delay than an equivalent investment of time spent in redevelopment prior to release. On the other hand, if he delays production until the equipment is perfect, it may never be released.

The second reason for having an accurate method to measure reliability is to spot trouble areas and determine the effectiveness of the *fixes* employed to overcome these troubles. Such preventive maintenance, to some extent, compensates for unreliable equipment. Engineers have noted that the reliability of complex electronic equipment is not constant for any extended time. Rather, it exhibits a cyclic nature, caused by the deterioration and instability of the circuits. Without a detailed knowledge

(Continued on next page)

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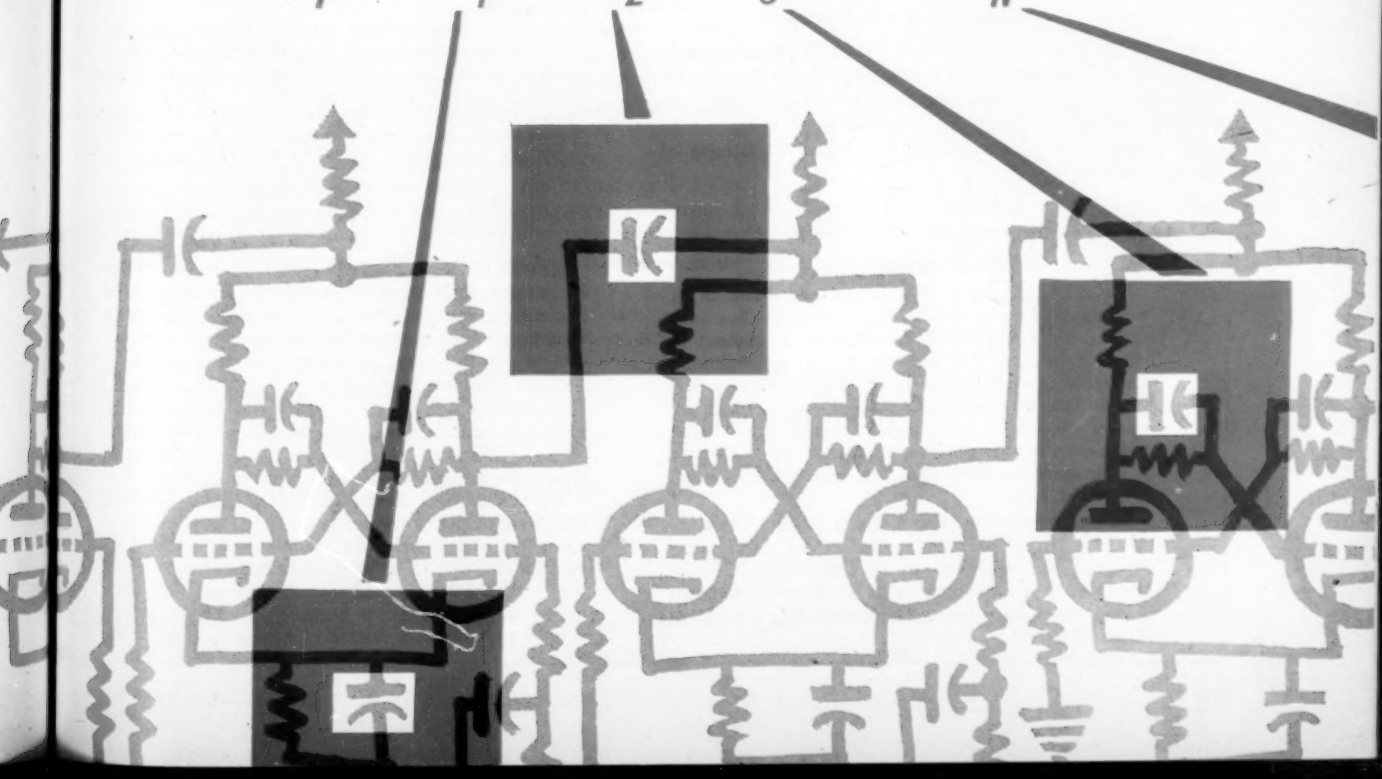
*The Systems Reliability Analysis Task Group of RETMA
A General Guide for Technical Reporting of Electronic Systems Reliability Measurement.

FIRST METHOD

$$P_T = P_1 \times P_2 \times P_3 \times \ldots P_N$$



(*Continued from previous page*)
of these fluctuations, maintenance men tend to either over- or under-maintain the equipment. Only by having an accurate picture of reliability performance can optimum maintenance be achieved.

Performance vs. prediction

Treating reliability as probability came about in an effort to separate performance and reliability. These are closely related factors, but they differ in a time sense. Performance, as historical fact, can be quite accurately measured. Reliability, as an expected or desired capability, must be predicted.

Reliability prediction is to electronic equipment as forecasting is to business. Both can be considered as educated guessing. But we try to put as much science into the art of guessing as we can. A complication arises, however, in the fact that we can alter the results of reliability prediction by changing the equipment. This point is dramatically brought home in the more advanced electronic programs where Model 2 is completed before Model 1 has been completely tested and the designer faces the dilemma of what to do about Model 3 currently being worked on. If ever a method were needed to predict reliability, it certainly is in cases such as this.

The scientific method of evaluation requires the controlling of variables so that only *one* is permitted to change at a time. This is an ideal of the experimental method. It cannot always be realized in actual practice, especially when dealing with complex systems. When the psychologist, sociologist, economist, the biologist, found directly controlled experimentation difficult, they turned to the field of statistics and probability. The reliability engineer, faced with a similar problem, has done much the same thing. The question he must answer is "Have we limited ourselves unnecessarily in obtaining a full understanding of reliability by defining it only as a probability and thus become powerless to measure it as anything else?"

Present method of measuring reliability

Generally the way we measure reliability is by measuring some function of the equipment's failure rate or its reciprocal, mean life. Failure rate is the frequency of failure occurrence which is observed over a period of time. Mean life is the average time between outages of the equipment.

There are at present three methods to measure reliability as previously defined. These are:

1. $P_t = P_1 \times P_2 \times P_3 \times \ldots P_n$ (i.e. The success-probability of the overall system (P_t) is the product of the individual probabilities.)
2. $P_t = e^{-t/m}$ (The exponential failure law, derived from the Poisson process.)
3. $P_t = \left[1 - \left(\frac{F_1}{T_1} + \frac{F_2}{T_2} + \frac{F_3}{T_3} + \ldots . \frac{F_n}{T_n}\right)\right]^t$
   (A simplification of the binomial expansion in which the probability of success equals 1 minus the probability of failure)*.

Where: P_t = probability of going time t with no failure
P_n = reliability of component n
m = observed mean time between failures
F/T = failures per time T (must be less than unity)

First Method:

$$P_t = P_1 \times P_2 \times P_3 \times \ldots P_n$$

Taken at face value this formula seems adequate to measure reliability. However, when we try to apply it in given applications we find we are forced to make a number of unjustified assumptions. The first assumption is that the individual component reliabilities P_1, P_2, P_3 . . . P_n are unrelated to each other. In a complex system this separation of cause and effect seldom exists. When a part fails it affects many of the other components associated with it at the time of failure. Nor is component

(*Continued on page 26*)

* Formula (3) proves useful in cases where there are a number of units in a system which have different operating times. Also this formula can be used where the failure rates are attributed to design deficiencies, manufacturing errors, component failures, etc.

If the probability of failure is the average failure rate we have;

$P = 1 - FR \qquad \left(FR = \frac{F}{1} = \text{Failure Rate}\right)$

Substituting this in formula (1) we find,

$P_{overall} = (1 - FR_1)\ (1 - FR_2)\ (1 - FR_3) \ldots (1 - FR_n)$

Expanding this we find

$$P_{overall} = 1 - (FR_1 + FR_2 + FR_3 + \ldots FR_n) \underline{FR_1 \times FR_2 \times FR_3 \times FR_n} - (FR_1 \times FR_2 \times FR_3 + \ldots) + FR_1 \times FR_2 \times FR_3 \ldots FR_n$$

In most of our work we have chosen to disregard the product terms leaving: $P_{overall} = 1\ FR_1 + FR_2 + FR_3 + \ldots FR_n)$

Formula (2) would yield a value of 0.224. Specifically, the error between the two methods cannot be greater than:

$$\frac{t\ FR_1 + FR_2 + FR_3 + \ldots FR_n)^2}{2!}$$

Some Definitions

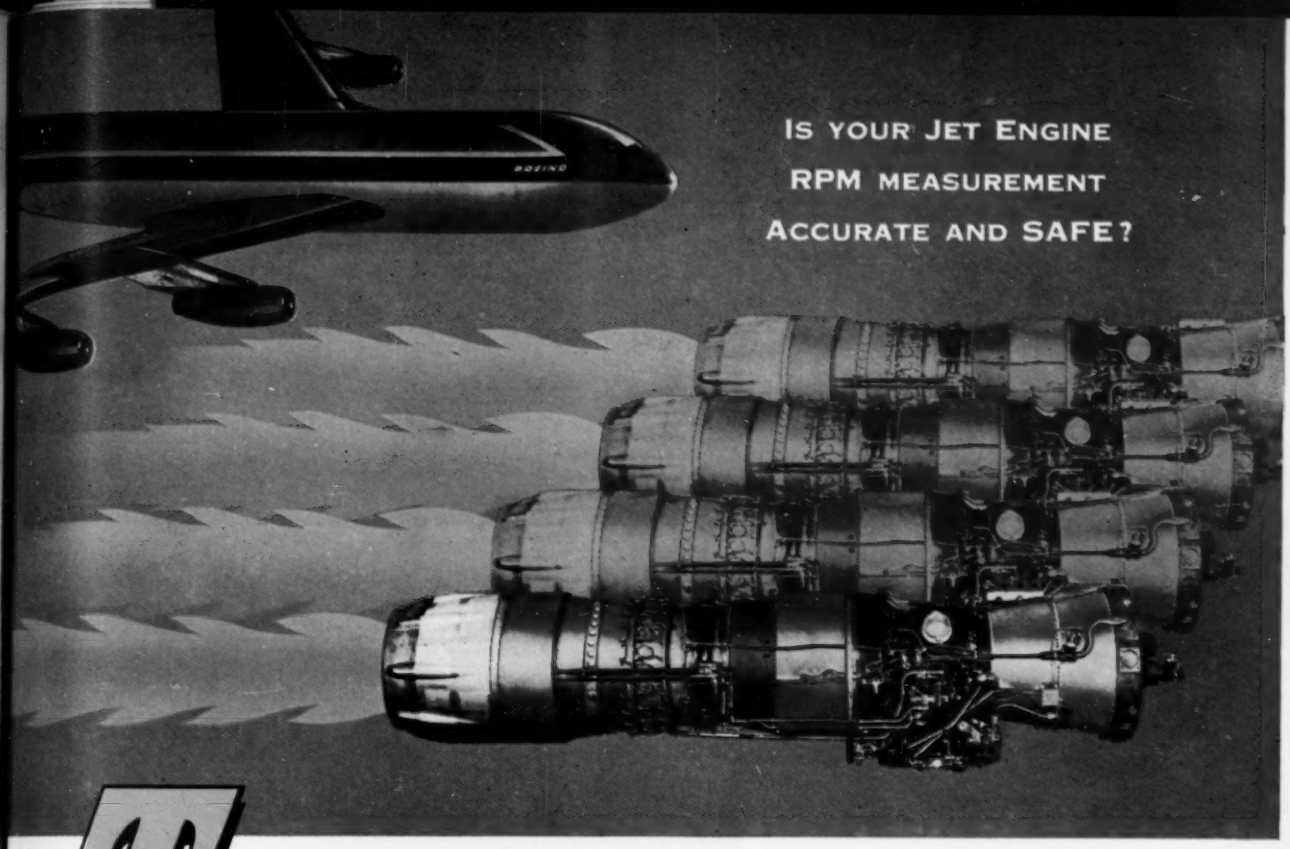
Reliability is a term applied to the condition of an equipment which is functioning normally. The precise meaning of the term depends on the context in which it is used. For common usage, reliability is that state in which there is an absence of observed trouble symptoms or malfunctions and in which all readily observable equipment functions are being satisfactorily performed. In this sense, reliability is considered to be a state in which there is an absence of trouble.

In the technical sense reliability is an ideal state in which all parts of the equipment are performing with optimum efficiency at all times. Such a state of efficiency is unlikely ever to be observed, but can be used as a standard for diagnosis and correction of malfunctions.

Malfunction is a departure from the normal state of reliability. It is characterized by a degradation in performance, accompanied by marked undesirable symptoms. Malfunctions may be caused by deficiencies in manufacture, operation, maintenance or by damage from external causes.

Reliability Analysis deals with the detection and diagnosis of departures from optimum performance of an equipment and aims at a description, prediction and control of equipment performance.

Reliability Engineering is that field of endeavor which seeks to understand the normal and abnormal operation of equipment in order to achieve the prevention and correction of malfunctions. Exact definition of the difference between normal and abnormal performance is difficult because abnormalities are simply variations in degree of normal performance.



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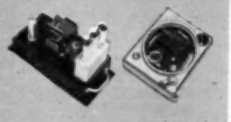

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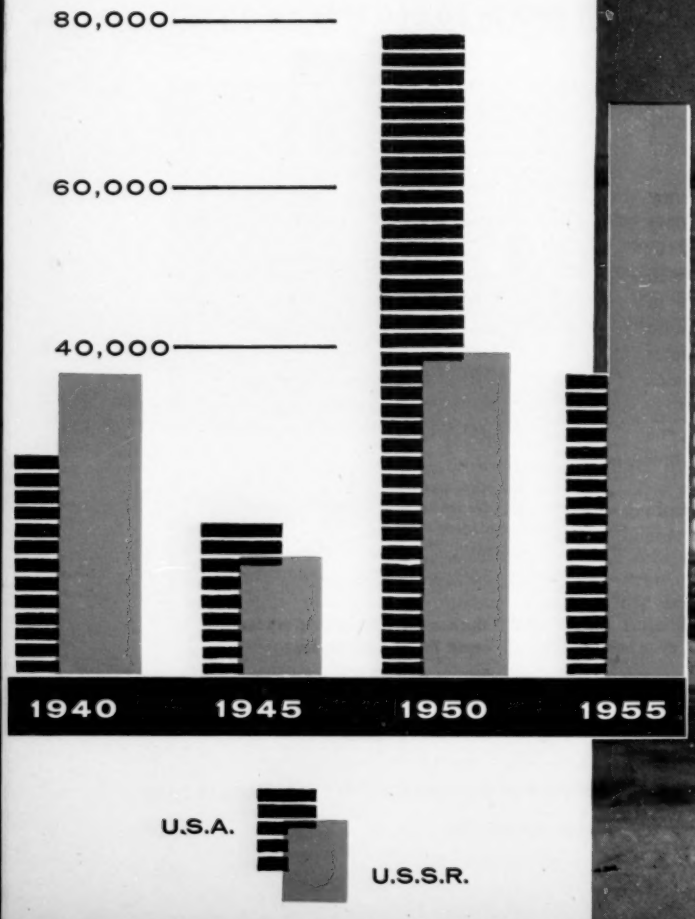
CIRCLE 7 ON PAGE 48 FOR MORE INFORMATION

Education for Enginee-

Russia's emerging superiority in engineering manpower is the result of U.S. decline in engineer output since W.W.II peak contrasted with Soviet's steady increase.



—U.S.S.R.

LAWRENCE SANDEK

AS THOUGH IT WERE A PLANE or missile, Soviet education is the object of continuing conjecture in the U.S. How good is it? How does it compare with our own? Is it better? Worse?

There are plenty of opinions on both sides of the question. Researchers at M.I.T.'s Center for International Studies conclude that scientific training in the USSR is spotty—excellent in universities, below our standards in engineering schools. That is substantially the opinion of Professor Roger Adams of Chicago University, who thinks that Russia may be producing more engineers, but that we are producing better ones. Agreeing that our engineers are better is Allen Waterman, Director of the National Science Foundation, who adds that we will even catch up in numbers.

On the other side of the argument is AEC Chairman Strauss who maintains that our technological lead is largely illusory. J. F. Victory of the National Advisory Committee for Aeronautics, testified before a House subcommittee that Russia's progress in training research scientists and engineers is such that within ten years she will have the best scientists, and more of them, than the U.S. Atomic physicist Edward Teller has said much the same thing, and, in addition, that it is already too late to reverse the trend.

Whatever the truth of the matter, observers who think that our technological lead is diminishing, attribute it to our educational set-up. They blame poor procurement practices, and underpayment of teachers. They point to wasted potentiality of students and potential students. They point to wasteful curricula and inadequate pay and prestige for engineers—and less for pure scientists.

These deficiencies have resulted in an undersupply of engineer-candidates, in overworked teachers in understaffed schools, in lack of interest in science as a career.

Russia has had similar problems. She jerked herself from a predominantly agrarian economy to an industrial one that rivals America. She accomplished that in 30 years. Among the problems she had to face were to find potential engineers, and then, having found them, to educate them.

Some, but not all of the devices she used to solve her educational problems are available only to totalitarian states.* Yet, there might be lessons for the west in the way she organized her resources.

Soviet Solutions

Russia has met the problem of supplying the lack of engineer-candidates by blocking almost all channels of social advancement. The channel she left open was education: as an engineer or scientist increases his knowledge or skill, he becomes more valuable to society and so rises through the otherwise fixed social strata.

Having in this way directed the mainstream of developing youth through the educational mill, she rigorously selects those from primary and secondary schools who are promising scientist material. The rest she shunts off into a tightly organized system of technical and trade schools. Those who qualify for higher education are mercilessly crammed with specialized technological courses, and encouraged with stipends and bonuses for superior performance. Sample result: the Kalinin Polytechnic Institute alone produces 500 metallurgists a year. Estimated entire U.S. output for 1957—about 700.

Having found—or directed—sufficient numbers of engineering students, Russia has met the problem of providing for their proper education by making teaching the best paid of

(Continued on next page)

*At least two informed studies of Russian educational practice recently have been published: *Soviet Professional Manpower*, by DeWitt, National Science Foundation; and *Engineering Education in the Soviet Union*, by a team of British engineers recently returned from a six-week tour of Soviet educational institutions. Their report will be published later this year in the Proceedings of the Institution of Electrical Engineers, Vol. 104, Part A, London.

all the professions and the most respected. The professor is better paid and has more prestige than his opposite number in industry. If he is inclined to some industrial work—consultancy or research—he may in that dual capacity earn an additional 50% of his base salary.

Hierarchy of Studies

Just as education in Russia is preferred and encouraged among the professions, engineering is preferred and encouraged in the fields of education. Engineering training institutions are the best equipped and the best staffed. They have priorities on new buildings, equipment, laboratory facilities, staffs, and so on. Within the engineering hierarchy is yet another gradation of preference, at the top of which are those schools which train engineers for key industries—armament production, metallurgy, atomic power, missiles. These are among the most difficult studies, but they are also among the most popular with students because stipends for them have been raised.

Technicums

The single-minded purposefulness of Soviet technical engineering education is also apparent in the way she has formalized educational opportunities that are alternative to higher engineering education. Her technicums are semi-professional training schools that produce technicians in narrowly defined fields.

Technicums work this way: students between 14 and 18 years who have not completed their secondary education and who are therefore ineligible for higher education, are siphoned off into these secondary semi-professional schools. Entrance is by competitive examinations. Here students are

(Continued on page 35)

Syllabus of Soviet Education Requirements

Russian emphasis on the technical, to the exclusion of the humanities and social sciences, is evidenced in this syllabus outline upon which are based entrance examinations for higher education. The information is condensed from the *Soviet Ministry of Higher Education Handbook* for 1956.

I. Russian Language and Literature

Phonetics, morphology and orthography, and syntax. Folklore and literary works (a long list of standard works is given, Shakespeare and Goethe are among the few foreign authors).

II. Foreign Language

Grammatical knowledge of English, French or German is required, knowledge of the literature is not.

III. Mathematics

Arithmetic and Algebra

1. Real and Complex Numbers—Factorization. Rational Numbers. Recurring decimals. Geometrical progression. Powers, metric system; units and proportions, Arithmetic and geometric means. Real number.[3] Complex numbers; geometrical interpretation and trigonometric form.

2. Manipulation of Algebraic Expressions. — Ability to deal with the forms

$(a \pm b)^2$; $(a \pm b)^3$; $a^2 - b^2$; $a^3 \pm b^3$

Factorization. Bezu's theorem on divisibility of polynomial by $(x - a)$. Algebraic functions. Radicals. Freeing a fraction from an irrational denominator. Powers with rational indices.

3. Inequalities: Functions and their Graphs—Equivalence. Properties of identities. Simultaneous linear equations with 2 or 3 unknowns. Quadratic and biquadratic equations. Formulation of a mathematical problem from physical data. Inequalities. Solution of inequalities of 1st and 2nd degree with 1 unknown. Functions. Variables. Graphical forms corresponding to

$y = kx$; $y = k/x$; $y = kx + b$;
$y = ax^2$; $y = ax^2 + bx = c$

4. Progressions. — Numerical sequence. Examples. General term. Arithmetical progression. Calculation of any one of its terms, and sum to n terms. Same for geometrical progression. Limit of a series. A geometrical progression summed to infinity. General sum for a geometrical progression.

5. Logarithms. — Logarithms. General properties. Graphical representation. Logarithm of a product, quotient, power and root. Logarithmic representation of a function. Properties of common logarithms. Calculations with tables. Solution of indicial equations.

6. Theory of Permutations and Combinations. Binomial Theorem—the relation

$$C_m^n = C_m^{m-n}$$

theory of permutations and combinations leading to binomial theorem.

Geometry

1. Plane Geometry — Includes the customary formal geometry of the straight line; triangle (right-angles and scalene); circle; regular polygons. Value of π.

2. Solid Geometry — Concept of planes and their intersection. The sphere, tangent planes; surface area and volume; properties of the great circle.

Trigonometry

1. Definitions and Basic Properties of Trigonometrical Functions — Degree and radian measure of positive and negative angles. Definitions of trigonometrical functions. Numerical values of the circular functions to be known for:

0; $\pi/6$; $\pi/4$; $\pi/3$;
$\pi/2$; π; $(3/2)\pi$; 2π

Relationship between trigonometrical functions of the same argument. Reduction of trigonometrical functions of a general angle to terms of an acute angle. Graphical representation of trigonometrical functions. Inverse trigonometrical functions.

2. Transformation of Trigonometrical Expressions and Solution of Trigonometrical Equations — Expansion formulae for

$\sin(\alpha \pm \beta)$; $\cos(\alpha \pm \beta)$; $\tan(\alpha \pm \beta)$

Trigonometrical functions of double and half angles. Transformations and reduction formulae for form $\sin + \sin$; $\cos + \cos$; $\tan + \tan$

(Continued on page 34)

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of industrial research

Sanborn's galvanometer writing arms record valuable data to help solve the countless measurement problems of research, design, and production testing.

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CIRCLE 8 ON PAGE 48 FOR MORE INFORMATION

FACE TO FACE

R/E interviews CHRISTENSEN of FEDERAL PACIFIC on Keeping Abreast of Giant Competition The New Product Gamble Ways to Lessen the Risk

Paul M. Christensen, Director, Research and Engineering, Low Voltage Products, Federal Pacific Electric Co.

QUESTION: What is the size of Federal Pacific?

ANSWER: We're a small company by comparison with the giants like General Electric and Westinghouse. Our gross volume is roughly 50 million a year at this point, and we employ about 3000 people. We are in the same class as the Square D Company, ITE-Bulldog.

What are the particular problems that a medium-sized company meets in holding its own against competition from these larger companies?

Well, the basic problem is the fact that although we make a broad line of equipment, they make a much broader line. They have established channels of distribution, which makes it easier for the customer to buy from them. Also the larger company has brand name recognition. More people know his name than ever know our name. That is obviously a disadvantage. So, to stay in business, you have to offer something that the large manufacturer can't deliver.

What sort of thing can the small company offer?

In some cases he can come across with better service. Occasionally, but quite rarely, he can deliver at a lower price. However, the major area in which he can compete is by concentrating on a limited range of products, and then offering a better product.

That puts the burden squarely on research and engineering doesn't it? How, in your case, would this have worked out? Can you give me an example?

The best example, in our company, was the introduction of a household circuit breaker at fuse-box prices. Traditionally, fusible equipment was standard as circuit protection. But fuses got this protection by destroying themselves. You had to replace them each time and keep a stock of spare fuses on hand. Non-destructive circuit breakers were on the market, but these were priced so high that most people preferred to buy a fuse and switch, and live with the inconvenience. The challenge, then, was to bring the circuit breaker down to the cost of the fuse and switch combination.

How were you able to do that?

Well, a number of factors were involved. First off, we had a fundamental design, developed some years ago, which lent itself to mass production, that is, to machine assembly. Federal Pacific had reached a point where it had begun to bump the ceiling of its potential on the existing line of largely fusible equipment—a few breakers here and there, but basically a fusible line, and that was that. So the question came to us—how are we going to grow? We can't do it with the existing line. Yet we didn't want to leave present markets. We're not particularly interested in establishing new product lines with new distribution problems. When you examine the field, the obvious direction was to transfer the emphasis from low cost equipment to quality equipment which has a very high price. If, by some chance, you could make a circuit breaker that would sell at competitive prices with the fuse, you could compete on highly favorable terms not only with the larger complete-line companies but with the multitude of small part-line companies making fusible equipment. In other words, you would expand within your same channels of distribution and compete favorably with the large manufacturer in a few basic lines.

What role did research and development play in this?

One phase was developing the design for the new product. But just as important was seeing that production would be able to make the device that we developed. Research and development does not concern itself solely

(Continued on page 18)

YARDSTICKS

Power Transient Analyzer

A compact, portable power transient analyzer simultaneously measures, displays and records generator output voltage, frequency, wave-form and power. The TA-120, provides directly, information that previously required several pieces of cumbersome equipment and a multi-step technique. Voltage and frequency error is less than 0.1% and less than 1% for a constant phase to neutral voltage KVA output. Voltage, frequency, and KVA are simultaneously measured under both steady state and transient conditions. Their ranges can easily be selected with calibrated, front-panel dials. Alexandria Div., Defense Products Group, American Machine & Foundry Co., 125 N. Royal St., Alexandria, Va.

CIRCLE 20 ON PAGE 48 FOR MORE INFORMATION

Supersensitive Indicator

As little as two parts per million of oxygen in hydrogen or inert gases, despite the presence of up to 3% carbon monoxide, can be measured by this indicator. In the device, gas being tested passes continuously over a catalyst which causes any oxygen present to combine with hydrogen. The increase in temperature caused by this reaction is measured by an extremely sensitive thermopile. The thermopile's output EMF is indicated and recorded by a potentiometer or can be fed into an automatic controller if desired. The gas is measured continuously by a rotameter and passed through a coil in a liquid bath to stabilize its temperature. If it does not contain enough hydrogen for test purposes, a small amount is generated by an electrolytic cell built into the indicator and automatically mixed in. Baker & Co., Grant Ave., E. Newark, N.J.

CIRCLE 21 ON PAGE 48 FOR MORE INFORMATION

Fiber Glass Housings

A new line of low-cost, small sized instruments for indicating, transmitting and controlling pressure and temperature will be housed in cases made of plastic-impregnated fiber glass, making them suitable for use outdoors or in corrosive atmospheres. Temperature range of the 1450 series is from —400°F to +1000°F. Pressure range is from 30" Hg vacuum to 5000 psi. As pneumatic receivers, the instruments can accommodate 3 to 15, 3 to 18, or 3 to 27 psi signals. Four controller options are offered: universal controller with on-off, proportional, differential gap and manual reset; wide band proportional: wide band proportional plus automatic reset; wide band proportional plus automatic reset plus derivative. Fisher & Porter Co., 951 Jacksonville Rd., Hatboro, Pa.

CIRCLE 22 ON PAGE 48 FOR MORE INFORMATION

Time Integral Measurements

An all-electronic integrating system has been produced which will measure the area beneath analog curves, to obtain the time integral of rapidly varying, short or long term analog signals. It is supplied as a portable or rack mounted instrument, giving accurate digital display of both the integral and the action time of the phenomenon being measured. Output connectors are provided so that the information can be automatically typewritten or fed onto tape. Its rate of 10,000 counts per second permits measurements of values over time intervals as short as 10 milliseconds. Allegany Instrument Co., 1091 Wills Mountain, Cumberland, Md.

CIRCLE 23 ON PAGE 48 FOR MORE INFORMATION

Measures Change Rate

Rate of pressure changes can now be measured directly with a new transducer system. Utilizing the electrostatic principle, the device permits precision rate or dynamic pressure measurements under the most severe conditions. Through the use of an adaptor and resistor element, the electrical current generated in the quartz crystal transducer is measured by an electrostatic type amplifier and displayed on a standard oscilloscope or recorder. It is especially useful for indicating combustion and detonation phenomena in evaluating engines and fuels. Kistler Instrument Corp., 15 Webster St., North Tonawanda, N.Y.

CIRCLE 24 ON PAGE 48 FOR MORE INFORMATION

Liquid Metal Measure

A liquid metal level indicator has been developed which is sensitive to 1 mm changes in height. Measurements are made through the wall, obviating the necessity for an internal probe. The indicator is based on a balanced inductance bridge circuit and can be adapted to different container wall thicknesses by varying the oscillating signal frequency. Nuclear Development Corp. of America, 5 New St., White Plains, N.Y.

CIRCLE 25 ON PAGE 48 FOR MORE INFORMATION

Tension Tester

A hand held meter which accurately measures tape tensions for use with magnetic tape recorders can also be used to test narrow fabrics, ribbons, carton tape and film. The tension meter has a range of 0-1000 grams with great resolution in the range of 0-200 grams. Measurements are made by pressing a trigger, inserting the tape, and then reading the tension upon release of the trigger. The face of the meter is easily read while the tape is running, stopping or accelerating. Tensitron, Inc., Harvard, Mass.

CIRCLE 26 ON PAGE 48 FOR MORE INFORMATION

BARBER COLMAN

Centrifugal Blowers

quickly dissipate heat from tubes, circuit components, other enclosed equipment

powered with Barber-Colman permanent magnet d-c motors

Having heat problems with electron tubes and other circuitry equipment mounted in confined enclosures? Install Barber-Colman permanent magnet centrifugal blowers for quick, dependable heat dissipation. Air volume for a typical unit is 20 cfm at 0 static pressure and 70° F. Voltages range from 6 to 115 volts d-c. Units available for either clockwise or counterclockwise rotation . . . several sizes, various mountings. Send for free technical bulletin.

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CIRCLE 9 ON PAGE 48 FOR MORE INFORMATION

FACE TO FACE

(*Cont. from p.* 16)

with the product design itself. It has to concern itself with the method of making the device and also with patentability and marketing. It's all part of research and development. So, the fact that this particular design lent itself very easily to automatic assembly tied in with research and development. Both the design of the product and the design of the machines to produce it at competitive cost went along on parallel paths. We didn't carry the product design up to a point, and then say to the machine designers, "Now you make this." There were two parallel paths. The design had to be capable of being assembled on certain machines because by the very definition of our objectives, the end product had to be at a cost level almost half of the existing cost of a circuit breaker.

How did you determine its cost that far in advance?

First off, you have a certain price you're aiming for—a better product than competition has, but at the same or lower price. In our case, the circuit breaker had to be better than equivalent fusible equipment—but sell for the same price. Then you figure the sales of circuit breakers and the total sales in the country of fusible equipment of that class. Now you are obliged to grab off a certain percentage of the circuit breaker business. This is essential, but not guaranteed. So there's a tremendous gamble in your re-tooling even before you have your design completed. It will cut into your own business, too, of course. Our fusible business would go down in ratio as our circuit breaker is going up.

So there was very clearly an overall policy objective set out at the beginning of this process?

Very definitely. Each gamble hangs on another gamble. You have to sell so many millions. In order to sell that many millions the product has to be at a certain price. It can't be produced at that price unless every step of the design comes out right. So, before you even start, you have to set those objectives.

Is there any information that will lessen the risk of the unknown in this planning?

Well, you can get figures from your own sales of equivalent apparatus. You also have available the figures from your trade association on the total volume sales of similar apparatus in the country. So from that then you know what your position is in the field. As for predicting your cost, you can anticipate the rate of speed that your new machines will operate. You determine this by asking people who know about machines. Then you figure your labor cost for assembly. You could figure out how many of these assemblies could come off a machine per hour and that establishes your labor rate; and then combine your overhead and so forth. Material costs, of course, are easy. We know relatively early in the development of this line that the goal was within reach. It was possible.

And what was the reaction when the product hit the market?

Very encouraging. When we decided to introduce the product, the machinery and the design were highly secret. Certain patent steps had already been taken. We entered the market on an area by area basis beginning in Texas, where there was a large amount in 1949 and 50 of relatively low cost residential housing. The industry was a little incredulous about the whole thing. Their first concern was that the product was inferior but we quickly established that it was not. Their second guess was that we were selling below cost in order to get established. Over a period of time they learned we weren't. In the meantime, we kept things highly secret. Competitors were not permitted in the plant during this period. Eventually, of course, they learned it was a good product and that the cost was right for the way we were making it, and they entered the business. But, in the meantime, we got the highly desired two-year or so edge over our larger competition.

Are they now entering the field with a product similar to yours?

They are now competitive with us, have been for two years.

Which, of course, brings you back to the problem of pulling another coup of this sort. How do you plan to continue to maintain your lead either in this particular product or another?

Well, of course, this is what happens. You can't hold an exclusive on a good product—a hard fact for the small

business, but it's what makes progress. In addition to continuing development on existing products, to keep alive, you have to keep jumping out ahead on one product after another. The others will catch up; and this means, you must start the cycle all over again.

What does the cycle involve?

First, it involves finding a new area in which the industry is relatively weak. A product may wear out too soon; it may be difficult for the customer to handle; it may be too complicated; it may be priced higher than necessary. But essentially, we try to make a silk purse out of a sow's ear. We look for products that are weak and can stand improvement. If you do that, you usually find that it's easier to start by identifying weak areas than to come up with improvements out of the air.

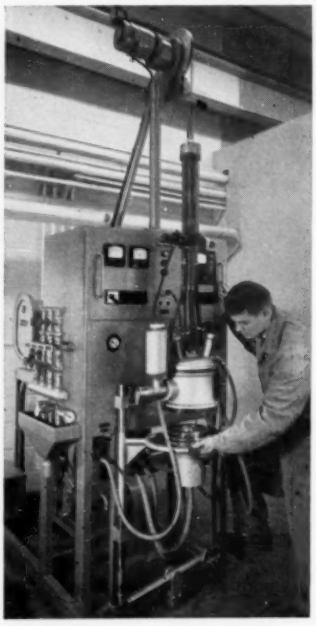
How do you identify the weak areas?

We get a lot of help from our sales force as it reports the complaints from customers and distributors. This is our main source. The customer, of course, is the final judge of whether a manufacturer stays in business. The way a small company stays in the running is by offering the consumer something he can't get from any other company. END

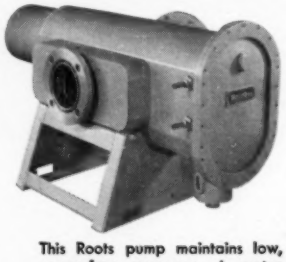
Holder of over 100 American and foreign patents, Mr. Christensen is director of applied research and engineering development for all low-voltage products of Federal Pacific Electric Co. He is a member of the Executive Committee, AIEE, and has been chairman of various committees of NEMA and for the War Production and Engineering Conference. Mr. Christensen took his BS in Electrical Engineering at Trinity College and has done graduate work at both Yale and Rutgers. During World War II he served on the Advisory Technical Committee, a group advising on the setting up of R/D departments. He has assisted in the preparation of many Industry and Technical Society standards.

Cr, Hf, Ir, Mo, Nb, Os, Pd, Pt, Re, Ta, Ti, V, W, Zr

Get pure vacuum melts of these metals *in minutes!*



The Heraeus Vacuum Arc Melting Furnace Model VA-L200C, smallest of a line of Heraeus Furnaces sold by CEC.



This Roots pump maintains low, vapor-free pressures. A motor operating within the vacuum drives its rotary frictionless pistons.

With this new Heraeus Arc Melting Vacuum Furnace, the VA-L200C, you can get vacuum melts in "buttons" or ingots.

You can get them of Titanium, Zirconium, Tungsten, and other metals or alloys with high melting temperatures. You can get them fast and pure.

Super-fast mechanical pump—A Roots mechanical vacuum pump pulls pressures in the furnace down to 5 x 10^{-4}mm Hg—*fast*.

Its throughput of 10,400 micron CFM at 10 microns easily handles sudden gas bursts encountered with certain metals.

No oil contamination—The Roots pump's frictionless rotary pistons require no oil sealing. There can be no contamination from backstreaming vapors in the system.

No crucible contamination—The Heraeus furnace has a water-cooled, copper crucible which cannot contaminate the melt.

Fixed or consumable electrodes—You may use either fixed electrodes of tungsten or metallic carbides, or consumable electrodes of the metal you are melting.

This Heraeus furnace has many other features valuable in laboratory or small-scale production, including exceptional economy—operating either under vacuum or with an inert gas atmosphere.

Heraeus of Hanau, Germany, has licensed CEC as exclusive agent for Heraeus Arc Furnaces (and Roots Pumps) in this country. Complete details in our Bulletins P8-20 and P4-28.

Consolidated Electrodynamics
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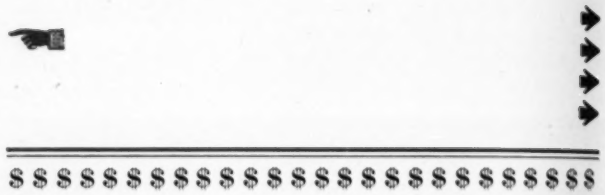
formerly Consolidated Vacuum

NATIONWIDE COMPANY-OWNED SALES AND SERVICE OFFICES

CIRCLE 10 ON PAGE 10 FOR MORE INFORMATION

Saving PRINTING Dollars



by CRETE DAHL

RESEARCH AND DEVELOPMENT DEALS with unrealized ideas. Thus, much of R/D's effort goes into making others understand what the product engineer visualizes. Reports, charts, diagrams, brochures, technical proposals, instruction manuals and patent agreements are all means by which he gets his ideas across to others. Whether these documents will be neat and accurate depends largely on the reproduction they receive. Assuring an excellent printing job at the lowest cost isn't difficult. It basically involves following a few important rules which your printer will enthusiastically endorse.

1. Compile a style sheet for your own company so that anyone in your organization who prepares copy for printing will do it in a uniform manner.

2. Have the complete job OK'd before calling the printer. This includes the required approval by the company officers and others who must verify statistics, copy, or model details. It also means having photographs and captions ready. Accompany the illustrations with a layout sheet to show where captions, margins, logotypes (firm name), or trademarks are to be placed.

3. Send only typed copy. It always costs more if the printer is required to do typesetting from handwritten copy because the job takes longer. Remember that it is harder for a stranger to read your handwriting than it is for someone who is familiar with it. Typed copy means fewer errors because your own errors will stand out more strikingly in typed copy than when buried in a maze of hastily-written penciled notes. Also, your printer can gage the amount of copy better when it is typed, in case you want an estimate before ordering. The most legible typing is double-spaced and on one side of the sheet only.

4. Have copy proofread by someone who knows the subject and product. If copy is important enough for an engineer to write it, it is important enough for him to proofread before it goes to the printer. You can't expect stenographers to know what the engineer has in mind, especially when the differences (as between microhenrys and millihenrys) are meaningless to the average civilian. If you send an unproofed copy to the printer, and the engineer catches errors in the final proof, it will cost you money. You can also

CHECK before printing:

QUANTITY AND SIZES: How many copies? How many pages? What page size?

PAPER: What kind? What color? What finish? Does the job warrant the expense of a glossy clay-coated finish? How heavily will the report be handled? How long do you want it to last? Are there any special requirements? (For example, it is desirable to print patent agreements on paper containing 50% rag or better. Rag paper does not tear easily, nor does it discolor as it ages.)

COLOR: When should color be used? Answer: When you want a change of pace . . . when you need different colors as a code to indicate a certain status for the job . . . when your forms must be used by more than one department . . . For example, the Standards Department of American Machine & Foundry Company prints tentative standards on salmon color paper; adopted standards on buff.

ILLUSTRATIONS: How many illustrations will be used? Will they be line drawing or schematic? How much will they be reduced in size? How about captions? Are drawings sharp and clean or do they require doctoring in order to reproduce well? Does each illustration require separate reduction or can two or more be positioned so they can be reduced at one time? This is a factor in buying engravings and in offset printing as well.

A quick SUMMARY of mistakes that increase printing costs:

Sending handwritten copy to the printer.

Failure to proofread copy before sending it to the printer.

Failure to double check printer's proofs.

Indiscriminate use of color, or ineffective use.

Corner blocks that run off the page and require trimming.

Author's alterations after the job is started.

reduce the cost of author's alterations by checking such things as the model number, statistics and so forth. Verify the accuracy of references between text and illustrative captions, and key the photographs or drawings with index and list of contents. Any changes that have to be made after the typesetting is done will cost you extra.

5. **Attach a specification sheet.** This should include specifications as to work required, such as quantity, kind and weight of paper, typesetting, headlines, captions, ink colors, and finishing operations.

6. **Estimate quantity carefully.** If you anticipate how you'll be using a printed piece, you can calculate with reasonable accuracy how many copies will be needed. It costs more to print two or more small orders than one of double size.

7. **Calculate the printed area carefully.** Sometimes the use of a slightly smaller type will enable you to reduce the number of pages needed for a given job. For example, American Machine & Foundry Company Standards Department in Greenwich, Conn. worked out a way of saving 20% of the cost of printing instruction manuals. Copy was typewritten with an electric typewriter onto oversize sheets, preprinted with the firm's name and spaced for identifying data. The entire sheet was reduced photographically to bring it down to 8½" by 11". The resulting type was just about the same as that used by newspapers.

8. **Use a semi-opaque non-oily paper for drawings** rather than a very transparent tracing paper. Pencil lines will show up better. Clearprint Tech Paper, No. 1000 PH is good. A T-square with beveled under-edge permits ruling without smudging. Don't draw one diagram over another. This causes ghost images. When using a tracing-paper pad, protect the underneath sheets by inserting a firm backing under the top sheet. A sheet of lucite or firm plastic will afford protection to the undersheet and a good drawing surface for tracing on the new sheet.

9. **Guard against losing important detail** by requiring too great a reduction. Plan to center the drawing and caption.

If the caption and code date are placed in a far corner of the paper, the printer will either have to reset the caption for you or reduce the entire area enough to take in both.

10. **Insure the return of your artwork** by identifying it on the back before sending it to the printer or engraver.

11. **When there is much description, save drafting time** and assure better reproduction by using either IBM or varitype for the big blocks of copy. These can be typed on a separate sheet of paper, cut out and stripped in with rubber cement, saving many dollars of draftsmen's time.

12. **Allow for wider margins along the binding edge** when planning schematics which are to be bound in a book. Using hand lettering, you'll get a sharper print job if guide-lines are drawn with non-reproducible blue pencil.

A final suggestion was learned the hard way. Avoid making a big production out of a little job. If everybody has to take a look at a piece being printed, let them kick it around before you send it to the printer, not after. A good guide to go by in making your own decision is this: All prices are based on receiving "copy ready for camera". Everything else that must be done costs extra.

Mrs. Crete Dahl, President of the Dahl Publishing Company, Stamford, Conn., heads her own printing firm which specializes in printing by photo-offset lithography. She works closely with several research firms and electronics manufacturers.

For ash determinations, fusions, heat treating and experimental test work, this furnace is a complete self contained unit shipped ready for use.

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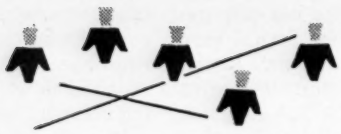


TECHNICAL MANAGEMENT *(Cont. from p. 6)*

New York to investigate the equipment of six or seven companies. He stays there four days and turns in an expense account with the following items:

Dinner	$7.00 every day
Taxis	4.00/day average
Entertainment	6.00 one evening (no explanation)

Would you call him in for an explanation or would you let it go? What would your approach be? What would you consider legitimate entertainment to support this charge? What would your company policy dictate? Let us assume that all other expenses appear reasonable to you. If we can get some discussion on this we should have some interesting points of view. I think it is timely to discuss these matters. Whenever an economy move gets started, the expense accounts come in for first-order scrutiny. I'd like to have some business manager or controller give us the legal aspects of expense accountability which might make bothersome explanations a necessity.

The Librarians Answer

The question which I posed in my January column, on the difficulties that arose between the engineer and the librarian, was provocative of considerable comment. It was most gratifying to hear from representatives of both sides. They all agreed that the situation should never have arisen and no one was willing to place the entire responsibility for trouble solely with either individual. The following comments were received from librarians:

Eleanor B. Gibson, Librarian, Carrier Corporation, writes as follows: "There are two important facts about the month's problem.

1. An engineer had further use for borrowed material.
2. The librarian did not fulfill her obligation to this engineer.

This kind of problem does not occur when engineers know that you as a librarian are trying to do everything you can to obtain information they need. Had the librarian's past dealings sold this engineer on this belief? I suspect not. Interlibrary loans are personal affairs. They also involve the 'good will' of an outside agency. Did she telephone Engineer Jones and explain this in a way that would make him sympathetic to the problem? I suspect not. Did she try to renew the loan? (This is usually possible.) Presumably the article was too long for photocopying. When she took the book in his absence did she leave a note reassuring him that she would borrow it again, from another source if necessary? When this librarian brought her tale of woe to the manager, was she saying, in effect, 'I am not equipped to handle my problems, and I haven't yet really learned that the number one rule of all dealings in all jobs is the Golden Rule?' I suspect so.

"To deal with the situation you take a close look at this librarian's assets and liabilities. Can she be salvaged? Is her weak point only that she is new and inexperienced? I suggest that she be asked to attend classes with supervisors who are learning your Corporation's personnel policies, or look for a librarian who can handle these little problems with tact and understanding.

"This incident might be avoided by careful selection of personnel. A librarian of average intelligence knows or learns that one gets nowhere by methods you have depicted: 'strife,' 'bickering,' 'disputes,' and 'wrangling.' If this type of problem is brought to management it indicates poor job performance. If an engineer's personality is basically overbearing, this will show up outside the library among his colleagues and superiors, and probably he will not remain long in the organization."

Lillian M. Cole, Librarian, Logistics Research, Inc., has this to say: "I believe the incident could have been avoided in one of two ways: (1) it would have been easy for the librarian to call Engineer Jones concerning the overdue book, or (2) if she thought it necessary to pick the book up herself, she could have left a note for him, explaining her actions.

"A few points which your librarian should remember: engineers usually don't have the time to read as much as they would like to; most libraries will gladly renew circulating material by phone, unless called for by another party; engineers, executives, librarians, typists, clerks—*no one* likes to have objects disappear from his desk—ugh! I can't think of anything more irritating and frustrating, except perhaps the old Chinese torture of a drop of water falling on your head every hour."

Mary Ellen Padin, Technical Librarian, Dunlap and Associates, Inc., makes a very important point every management should consider thoroughly: "I suspect that the instance that you cite might well have been avoided by a little dollars and cents thinking. In the case of a magazine article, photocopies are available from large libraries such as the New York Public Library for a dollar or two. If the librarian had considered the time spent in borrowing and returning at her dollar per hour rate of pay, added to the postage or messenger rates, and the wear and tear of the ensuing hassle in which she encountered some 'Rudeness,' she would have saved the company money even if the copy cost several times several dollars. We keep a deposit account with the New York Public Library and simply write off their cost as a saving in time and general confusion. Perhaps management has been at fault in this case to some extent by pulling the strings on the library spending fund and not educating the librarian to consider her time as being just as expensive to the company as the dollars that are spent on printed paper."

Replies from Engineers

Whereas the librarians with a few exceptions gave sound advice on how to avoid the problem, the engineers answered the questions about how to deal with the situation presented in the case.

One suggested that the manager needed to get more facts by asking questions of the librarian and the engineer separately. All recommended bringing them together for a conference to explain the problem and develop a method of preventing future hassles. This has been advised by W. B. Wade, Plant Manager, General Mills, Inc.; W. H. Burnett, Hogan Laboratories, Inc.;

and John D. Barney, Design Engineer of Aerojet, General Corporation.

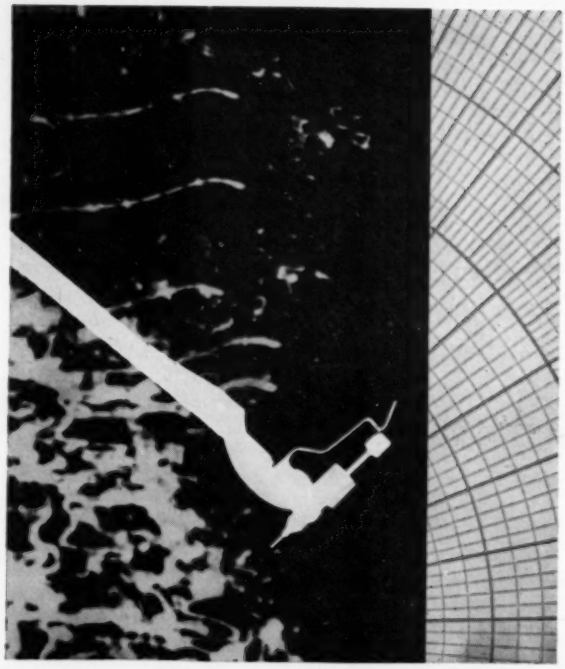
Now for some interesting observations, as gleaned from the letters: One suggested that the engineer's supervisor should be brought in by sending copies of the second and third library notices to him (Robert G. Hall, Engineer, Cascade Research Corporation). Many stressed that the book should not have been removed from the desk; this being only common courtesy. "The engineer failed in communication in not making his need clear." Perhaps "the engineer lacked an understanding of the library's rules and requirements." (From engineers).

"Apparently the librarian you picture is not very understanding herself and certainly is much too sensitive. A minor problem such as this should never have gotten to the management level. However, since it has, the librarian should be told to exert more effort in making technical personnel aware of library policies and procedures." "Above all, the Librarian should operate on an equal technical level with the engineers and thereby not fall in the position of 'custodian' to a collection, but rather an 'interpreter' of the collection. Management's attitude can contribute to this objective, but it is essentially the Librarian's attitude that determines the opinions of and relationships with the engineers." "Too often, management, with its many problems, fails to recognize the benefits and responsibilities of a good Library. In like manner, too many Librarians forget that their function is to be of service and not to have shelves with every book in place." "My own solution was a square dance—we are 'buddies' now." (From librarians).

Technical Librarians Needed

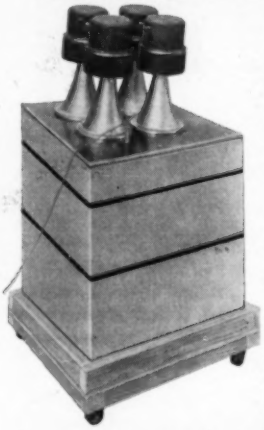
As an "educator" now (nine months since I entered University life) I hope I may be pardoned if I conclude with the following quotation from Mary Ellen Padin of Dunlap and Associates, Inc. "It would be well for management to consider diverting some of the vast sums being spent on engineering recruitment to publicizing the need for technical librarians. My own experience has been that it has never occurred to science educators that libraries offer excellent career opportunities. I'll go even further and say that it was probably a shock to some of my professors that a "librarian" could pass their course . . . to say nothing of meeting the catalog prerequisites! In these days of the mass recruitment drives that descend regularly upon our schools it would seem that management could do much to improve communication between the library and the engineering department by making known their need of engineering talent for their libraries. It is not enough to visit the library schools for there are already ten jobs waiting for every library school student with *any* science background." END

Formerly Research Director for Burroughs Corp., Dr. Williamson is now Dean of the School of Engineering and Architecture of Pennsylvania State University. He also acts as a consultant on problems in technical administration to industry.



high intensity sound
measurement and generation

The environmental testing of electronic and mechanical components subject to high sound pressure levels has become a major factor in many development and manufacturing programs. Altec Lansing Corporation, Department of Advanced Engineering, is engaged in a comprehensive program to provide the equipment and instrumentation necessary for both the measurement and analysis of high intensity sound and the generation of such sounds for environmental testing and experimentation.



Typical of the products resulting from this program is this Environmental Sound Chamber. Powered by four Altec 20801 driver units, the chamber develops a sound pressure level of 150 decibels throughout the range from 600 to 3000 cycles per second. Substitution of other driving units provides an equal pressure from the 30 to 600 cycle range. Sound pressure continuity is within 3 decibels throughout the chamber; power is provided by 260 watt Altec amplifiers using either single frequency or octave band sources; exact sound levels and characteristics are measured within the chamber by an Altec 21BR series microphone.

This chamber is one of the hundreds designed and built by Altec to meet specific requirements. Your inquiry is solicited regarding our regular products for the generation and measurement of high sound levels or for the research and development of special products suited to your exact problems in this field.

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SO YOU'RE GOING TO MAKE A SPEECH
Research & Engineer

ELECTION RETURNS!

uct cess development...in 1956

In the January and February issues, we reproduced—as at left—the articles only on technical management which were published in R/E during 1956. The 26 titles were listed—a ballot was included—and you, the readers, were asked to vote on those articles which proved most effective. In addition to the 26 feature articles, we included the regular monthly department "Technical Management" by Dr. Merritt A. Williamson.

A TOTAL OF 2,731 VOTES WERE CAST

On the average, each ballot checked 18 of the 27 as being "extremely helpful" or "very interesting"—from which we conclude that 2/3 of the management articles hit the bull's eye with the majority of R/E readers.

Here are the first three winners:

1. **The DP Problem: How to Handle the Difficult Person in Engineering 86.6%**
2. **Time Management for the Research Executive 84.0%**
3. **How Do You Rate As An R/D Manager?....83.3%**

But it was close!—There was a spread of only 59 votes between the highest and lowest scoring articles.

In the special category for Dr. Williamson's "Technical Management" series, over 61% of the readers voted for this department in one of the four categories shown on the ballot.

To each of you who filled in and mailed the complicated ballot: our sincere thanks. The poll was taken to obtain another yardstick for editorial guidance in the engineering-management part of R/E editorial content, and the informaton in the large number of returns has already been put to use.

Although comments were not requested, on 74 of the ballots readers added personal opinions. All of these comments—brickbats as well as bouquets—are given in the surrounding columns.

UNSOLICITED COMMENTS FROM READERS:

"R/E one of my favorite publications. Bouquets to art and typography guys."

"An excellent magazine all around!"

"Have derived much good from your publication. Many thanks."

"Your publication gets more attention both as to text and ads, than most purchased publications . . . because the problems treated are more nearly the actual ones of R/D managers than purely technical matters."

"Products listing (new gadgets, etc.) seems a little out of place in your magazine."

"Keep up the good work— I like your coverage of new products."

"Good job."

"I find the whole issue of interest every month."

"Yours is the first journal written for the R & D man, other than society pub's. I appreciate your emphasis on quality instead of on 'number of editorial pages.' "

"Find your magazine most helpful and interesting."

"Excellent work—keep it up!"

"Your articles are excellent."

"I like R & E."

"Most refreshing technical magazine I read."

"I consider this the best journal I have ever read."

"Keep up the good work."

"All around you have a very helpful and interesting publication!"

"Exceptional magazine—read every issue cover to cover."

"I circulate my copy of R/E and it is well received."

"An excellent magazine in all respects."

"I read 'em all!!"

"Wonderful—Please Keep it up!"

"R & E was excellent in 1956. Keep up the good work."

"Congratulations on maintaining a high percentage of readable material."

"Very useful publication."

"Look forward to receiving the magazine. Most useful and very good."

"Just keep up the good work."

"R/E magazines are extremely good easy reading."

"You have an excellent informative publication."

"Too much stress on aircraft and missile industries."
"The selection and variety of subjects have been excellent. If they continue in the future as in the past there is little in the way of criticism that can be offered. The R & E publication is my most reliable reference for info. concerning my daily problems."

"R/E is the most interesting, varied magazine I receive—like it enormously—format excellent."

"Good magazine — stimulates diversified thinking."

"It would be difficult to suggest improvements—R & E is excellent."

"The 1956 issues have been very much in demand throughout research administration, even ahead of regular library service. My personal copy is invaluable."

"R and E covers the management side of research and development in a way no other publication does. It fills a real gap in the literature."

"If I were reduced to receiving only one magazine, this would be it."

"I enjoy every issue and notice constant improvement."

"R/E is an outstanding publication and I usually read cover to cover."

"An excellent publication— enjoy it very much."

"R/E exceedingly valuable—look forward to reading each month."

"Yours is the best of the technical management publications I receive. Well done."

"Think you have done an excellent job thus far. Let's have more of the same."

"Most excellent magazine."

"I think your magazine fills a very great need."

"Excellent magazine & material."

"General level of the magazine is very high. Look forward to reading it."

"Like your magazine very much."

"Excellent magazine throughout."

"Most helpful magazine!"

"By all means, keep this magazine coming."

"Your publication, Research and Engineering, is most helpful and as indicated in my ballot, please keep it coming just as it is."

"Fine magazine! Keep the good work up!"

"I like R/E ! ! !"

"Enjoy reading R & E very much."

"Very interesting periodical."

"You are doing an exceptionally good job in choosing and writing up your subjects!"

"Excellent publication."

"I find R/E one of the most stimulating periodicals that I read."

"R/E is one of the most valued publications in this office."

"Very good articles to date—excellent publication."

"Magazine very helpful with present contract."

"Technical articles very good—keep it up."

"Enjoy your publication very much."

"Your magazine and content is superb."

"Enjoy and find R/E more profitable than any other."

"Here at last, I found is a magazine that is doing a service rather than just clutter up an over-cluttered desk. In general, the articles are of exceptional quality and furnish information of precisely the type research men need, and, incidentally, cannot find. Though it is seldom realized, the management, administration, and justification of research are difficult and important to doing the technical work itself."

"Generally, the magazine has been quite useful and interesting."

"You're doing fine."

"I like R/E because it deals with problems of a higher and more general nature than most publications, and deals with them in a very readable style."

"Excellent magazine—keep up the good work."

"Generally fine magazine!"

"R & E is filling a real need by focusing on management of research."

"I think this is an excellent publication."

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At Hawthorne, in Southern California, Northrop Aircraft has a continuing need for experienced engineers seeking new opportunities. There are attractive positions open in the following fields: Aerodynamics, Dynamics, Thermodynamics, Stress, Loads, Performance Analysis.

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You'll be associated with a high-calibre engineering team that has established an outstanding record in aeronautical design and development. Your initiative and ideas will be recognized, encouraged and rewarded, for at Northrop Aircraft the progress of personnel is as important as the progress of projects.

Besides attractive remuneration, you will enjoy other benefits unexcelled in the entire industry—retirement plans, health and life insurance, college educational reimbursement plan, regular vacations plus extra year-end vacations with pay. Easily-reached mountain, desert and beach resorts in sunny Southern California offer year 'round attractions for you and your family.

You will find the career opportunity you are seeking at Northrop, pioneer in the design and production of all weather and pilotless aircraft. If you qualify for one of these attractive positions, contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600-A1, Hawthorne, California.

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Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

5-A-89

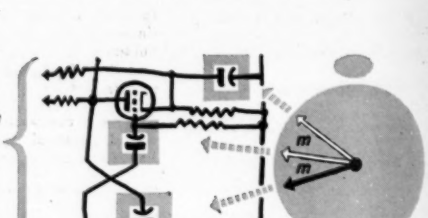
(Continued from page 10)

failure the only cause of equipment failure. There are also functional-type failures, where the equipment is incapable of performing its assigned task even though no individual part has *failed*. An example of this would be a sensitive circuit which depends upon the root-mean-square of the tolerances of individual parts to furnish the desired accuracy. Another example would be a critical circuit which lacks adequate design centering and "parts selection". A graphic example is a quantity of perfectly good tubes left over at the end of a production run that did not quite yield the desired performance value set up in the test specification.

How valid is the method used to determine these individual components reliabilities? A laboratory-controlled experiment has several limitations. It assumes that environments can be accurately simulated and simultaneously applied. It also assumes that the cross-effects of associated components can be factored-in: nor does it consider that identical parts have different points of failure depending upon their applications. For example, a 5% resistor may in the laboratory experiment be considered as having failed when it deteriorates 10% of nominal value. In its circuit application this same type of resistor may not fail at 20%, 30%, or 100% deterioration. In fact, there will be cases where the equipment will not fail even if the resistor burned-open or shorted-out. Recognizing these difficulties, we might use tables of failure rates of components determined in actual equipments employed in similar environments.

Other questions are also left unanswered. Will the components have the same reliabilities in new design as they did in the design from which the data were taken? How should we treat those parts which were replaced by efficient maintenance men before they actually failed? By the time we have separated components into their various groups and circuit applications, do we have enough failures to be statistically significant? An actual check of 50,000 failures covering a two year period of operation revealed that a group of 30 search radars had only 4 paper capacitors that failed and each of these was a different type. This certainly is not a large enough quantity upon which to base valid failure rates.

$$P_t = e^{-t/m}$$



Second Method

Let us consider the second formula in the same critical light. This method requires a random distribution of failures. To satisfy this requirement we must assume all the failures occur by chance, or there must not be any inherent weaknesses in either design or components. Therefore, we must assume that all failures are caused by internal stresses and none from external causes. By assuming this, we are assuming that interaction does not exist, and we sacrifice the possibility of accurately finding the effects of components interaction. Certainly, as a system becomes more complex, the nature of the

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system governs the relation of the components more than does the nature of the individual components. A component tends to lose its independent identity when it becomes part of a complex system.

One of the most serious drawbacks of this as well as the other two methods is that none of them takes into consideration the length of repair time of simultaneous failures. In continuously operated equipment such as search radars, we may have, for example, ten failures in a ten-hour period. Conventionally, this would yield an hourly reliability of: $P_{1hr} = e^{-1/1}$ or 36%. If all these failures occurred at the same time, the system would only "experience" one failure and the reliability would then become $P_{1hr} = e^{-1/10}$ or 90%. Therefore, depending upon when in time these ten failures occur, we have a reliability "difference" of 54%. Now consider the possibility where each of the ten failures requires one hour to repair and each failure occurs every hour. In this case the equipment will not operate at all during the ten-hour period.

Assuming that the overall reliability of a system could accurately be measured, we would still not have the insight or understanding necessary to realistically *predict* its performance. We generally treat reliability as a complete entity. This may be acceptable and adequate in determining degrees of contractual compliance.

In conclusion

Desirable as it may be to measure the reliability of an equipment as a whole, we cannot do this unless we isolate the factors that combine to result in reliability. Once we achieve this isolation, we face the larger and more difficult task of relating the inter-effects of individual components to each other and to the equipment as an entity. Components in this sense include both physical parts, such as resistors and capacitors as well as performance traits such as repairability and stability.

The scientific method calls for varying one parameter at a time and holding all others constant. In complex systems this is difficult to achieve. To assist in this effort we can use the technique of factor analysis, analysis of variants and co-variants. These procedures recognize simultaneous variations of a number of factors and can be applied in reliability investigation. Analysis of covariants allows the factoring-out of certain related but uncontrolled variables which are not of interest in a particutar investigation.

In these multivariants analyses we not only find the quantitative value of each factor but also the extent to which each one contributes to the end result. This yields a method to separate and rank these parameters which have the greatest controlling effect so that corrective efforts may be more beneficially applied. END

This is the first of two articles on Reliability by Mr. Landers. The second article will appear next month.

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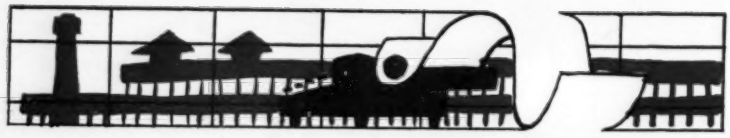
CIRCLE 63 ON PAGE 48 FOR MORE INFORMATION

In the advance of science, publication is second only to discovery. Scientific experiments must be published before they can be duplicated or corroborated. Here R/E reports how forty companies overcome literary lethargy.



SCOTT NICHOLSON

THE SCIENTIFIC LITERATURE which a country produces is a good indication of the vitality of that country's science. There are several reasons why this is so.

One reason is that most productive experimenters, from Pasteur to Riemann, have tended to be voluminous writers. In a recent study of scientific literature, Nobel prizewinner, William Shokley, observes that "Studies demonstrate surprisingly close correlation between quantity of scientific production and the achievement of eminence as a contributor to the scientific field.*

Also, published articles bridge the information gap between scientists. They afford a means by which scientists working on the same problem in different labs can exchange information. And this process of keeping abreast of the latest developments is essential to current progress.

Finally, a vigorous scientific literature aids a country's long-range scientific growth. As E. K. Gannett, Managing Editor of the Institute of Radio Engineers points out, "Scientific writing renews thinking. By placing knowledge on record for ten years hence, it preserves the germs of useful ideas so that someone later may pick up where the last researcher left off and pursue the idea along a new line of development. That's the way scientific progress occurs."

Cause for Concern

How is America doing in this important phase of science and engineering? A few years ago no one would have bothered to ask such a question. America and Western Europe stood almost alone as the chief contributors to the literature of science. However, if the latest reports from the Academy of Sciences of the U.S.S.R. are to be believed, the Soviet Union is rapidly overtaking America in both the publication of original manuscripts and the abstracting of scientific journals. Last year the All Union Institute of Scientific and Technical Information, Russia's scientific information center, boasted that it furnished complete coverage of 400,000 papers to Russian scientists. Though the majority of these may be translations of back-dated Western papers, none-the-less, contrasted against the estimated 5,000 papers written in the fields of electronics, chemistry and mechanics in the United States last year, this figure must give American scientists pause. The Western World's output of meritorious scientific writing is even smaller. Last year, the Department of Scientific and Industrial Research in London, the Western World's major center of scientific literature, reported that it abstracted 3,900 papers of special merit produced in American and Western Europe, of which less than half were authored by Americans.

The Role of Business

Is there any explanation for this lag in America's intellectual efforts? Interested observers here have come forth with several answers.

Many place the blame on government security regulations. The Defense Department and the A. E. C., this argument goes, have classified the very information which is most needed. One scientist at the Army's Redstone Arsenal—cleared through top secret—pointed out to a R/E reporter that the best way to maintain one's access to classified information "is *never* to publish."

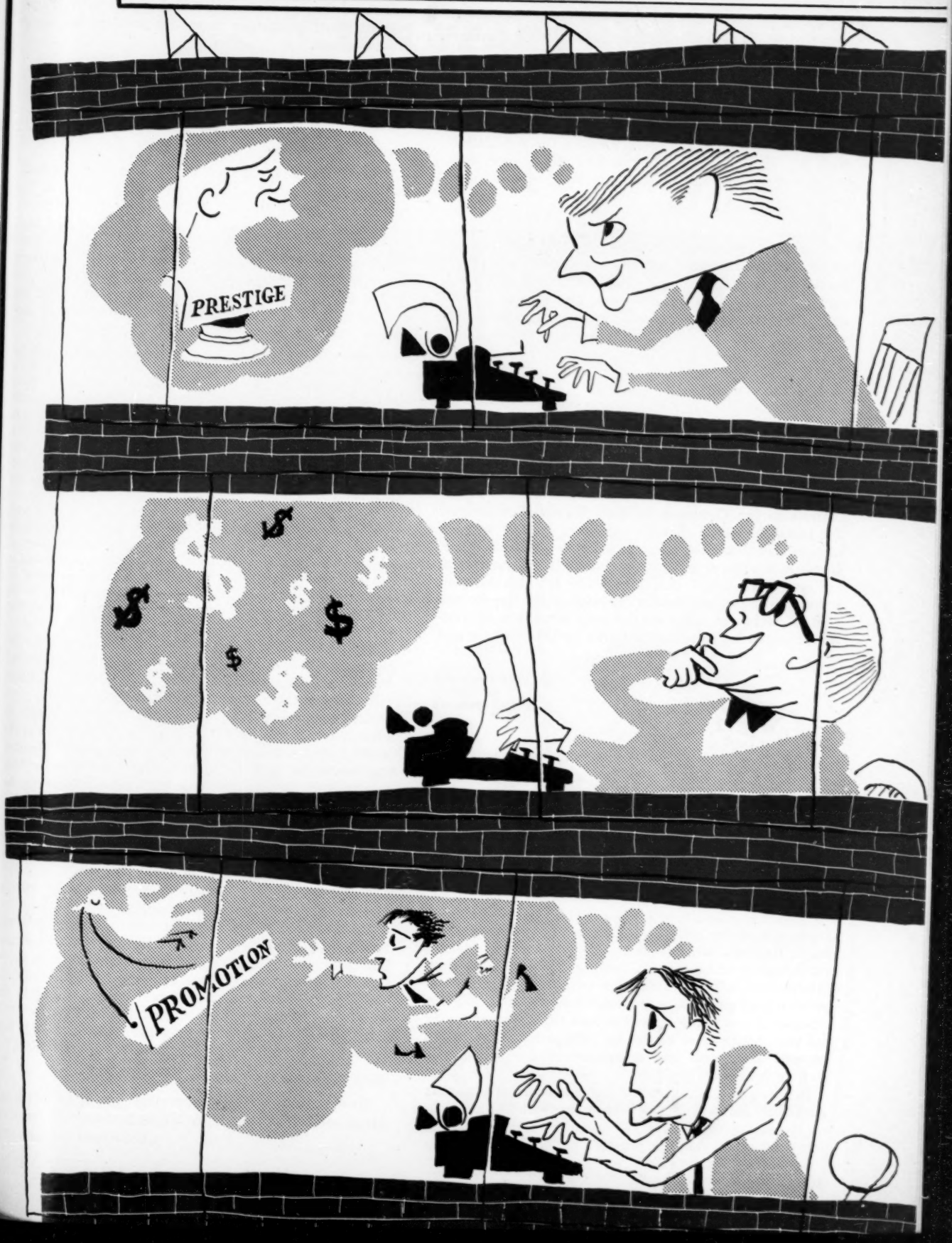
But probably the brunt of the blame is being borne by that standard whipping boy, the U. S. corporation. Informed engineers have accused companies of unintentionally interfering with the publication of scientific literature. One widely held view, for example, is that public relations and sales departments turn most technical writing into promotional literature. As an official of the Grand Central Rocket Company, Redlands, California, points out, "Engineering articles should be purely for information and not oriented toward the interest of sales. When they are directed towards sales, the information becomes slanted and impedes the scholarliness of the articles."

Researchers also complain that companies encourage scientists and engineers to be secretive about new processes and inventions. As George A. Stetson, editor emeritus of the ASME journal says, "Just two decades ago the incentive was all toward publishing. The scientist made a reputation for himself in his field by writing papers. Today most men seem to get ahead in their company by inventing, but being very careful not to disclose

(Continued on page 30)

*On The Statistics of Individual Variations of Productivity in Research Laboratories.—*Proceedings of the I.R.E., Volume 45, No. 3, March, 1957.*

Authorship & Company Policy



Authorship & Company Policy

(Continued from page 28)

any of the processes and products that result. Today the incentive is all toward nondisclosure of secrets rather than disclosure."

Finally, companies are accused of depriving scientists of the incentive and time to produce literature. Technical men, this argument says, are kept so busy producing research for the company, that in many companies there is no time for individual work. Credits for publication must be given to the company and to other nonwriters before companies will approve the publication of the paper.

R/E's Survey

How valid are these criticisms? To find the answer, RESEARCH & ENGINEERING some time back polled forty companies in many parts of the United States regarding their publication practices. The results of this survey reveal that these complaints are for the most part unjustified. Actually, companies in R/D are doing what they can to help their engineers get experiments into writing. Eighty-one per cent of the responding companies reported themselves actively encouraging their engineers to write for publication.

From the standpoint of patent protection, keeping new discoveries secret is not always advisable. Many companies deliberately encourage their engineers to publish new inventions in order to reinforce their claims of patent priority. The patent department of the M. B. Manufacturing Company of New Haven, Connecticut, for instance, insists that its engineers publish as soon as possible after developing a product or process because, in patent law, prior publicity is nine-tenths of ownership.

Finally, the belief that companies are discouraging individuals from publishing is refuted by the 43 per cent of companies. They see the main advantage of writing to be the improvement it works on the thinking and

Today, non-disclosure of secrets is the tendency

expression of the individual engineers. For example, Dr. W. E. Hanford, vice president of Petroleum and Chemical Research of the M. W. Kellogg Company says that "Only through publication does an individual maintain his own high technical standards." And Dr. T. H. Rogers, director of research for the Standard Oil Company points out that "Authors of papers for publication write better reports. They need the experience of organizing and writing for a wide audience."

In short, R/E's poll of forty companies indicates that American industry is very concerned with the problem of increasing the number of technical articles written for publication. Only 20 per cent of R/E's respondents reported doing nothing to promote writing of scientific literature. The great majority are pushing positive programs to encourage engineers to write for publication.

How do they go about this? The replies to R/E's poll indicate most companies meet the problem by one of three systems.

- **an engineer writing fund**
- **a professional editing service**
- **a publications committee.**

Writing for Money

According to R/E's survey, some companies have established writing funds to induce engineers to write. The company pays its authors a fixed fee for a minimum number of words. In most cases, in order to get paid, the author is required to do the writing on his own time. Also, the subject of the article must be about something other than his normal work.

The advantages of an engineering writing fund are set forth as follows by the Convair Company of San Diego, California:

"Under the former system, we found engineer-authors tended to slant their writing toward the periodicals which paid the largest fees, with the result that papers were being submitted to relatively few editors, and not always to the publication best concerned with the article subject. Since, in Convair, payment to the author is standardized—at a price comfortably above the going rate (we found the average honorarium well below $100 per article)—the author can submit articles without regard for financial return to the most suitable publications.

"From our standpoint the system has worked very well. In the half of 1956 during which the fund was actually in operation, we authorized more than twice the number of payments for which we had budgeted at the outset. And in that half year more than doubled the number accepted by reputable magazines during the twelve months prior to the May starting date of the fund. Also paying men for writing gets the writing done."

"If the article can be paid for in cash," adds the Director of Research of the Electro Refractories and Abrasives Corporation of Buffalo, New York, "the men will write on their own time—otherwise not."

Most companies, however, look upon writing funds as a needless expense. Said the chairman of the publications committee of a midwestern chemical company: "The men who write for money, I don't believe produce as high quality work as those who are motivated simply by the reputation in their field."

A somewhat different objection is expressed by an official in the American Machine & Foundry Company, who argues that paying money for articles simply takes men away from their regular duties. "If we gave money for writing articles," he laconically commented, "that's all those guys would ever be doing."

Finally, many companies feel that the problem is not to stimulate quantity of scientific literature but to stimulate quality. Said the research director of a North Carolina textile company, "There are very few really significant articles written. And the real trouble seems to me to be in improving the writing quality so that men will not have to dig and sweat as hard in eking the few morsels of information out of an overstuffed article."

Help from Editors

How can companies improve the quality of writing? Many companies answer by hiring professional technical

(Continued on page 32)

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Authorship & Company Policy

(Continued from page 30)

writers. These men, usually amateurs in science, are specialists in language. They work exclusively on polishing the writings of engineers. They may be on the public relations staff or members of technical writing divisions.

Companies find that such men are useful in several ways. For one thing, they frequently produce more readable reports. Because the technical editor is a specialist in writing, he often knows how to express ideas simply and clearly. Also since he's a layman, he is more aware of points that are difficult to understand. As a result, the work he edits is frequently well received by the average audience.

Another advantage of the technical editor is that he can help engineers to meet their writing deadlines. Because he works exclusively on writing, he's not diverted by other activities. Thus, he can push ahead on writing projects much faster than can the engineer, who is often overloaded with the demands of his work.

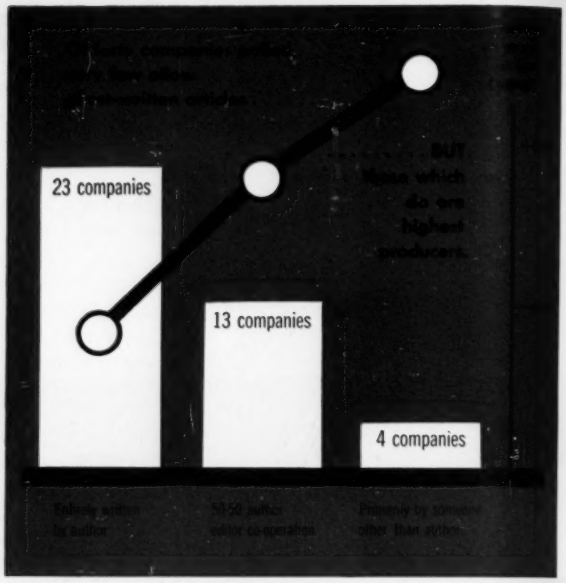
Finally, many companies feel that having a technical editor on the staff saves money. The technical editor's time is less valuable than the engineer's and he can serve the writing needs of several engineers simultaneously and save the overall time investment of these men.

However, many R/D managers see decided disadvantages in the use of technical editors. For one thing, reliance on them too frequently evolves into out-and-out ghost writing. This means that the engineer authors his articles in name only.

Since one of the most significant values which an engineer receives from writing for publication is the practice he gets in clear and orderly expression of ideas, many R/D managers feel that the engineer loses this training if an editor takes over the task. Says Dr. T. H. Rogers, Director of Research for Standard Oil Company, "Authors of papers for publications write better reports also; and they need the experience." An official of Philco Company adds, "In these days of cluttered communication channels, the clarity with which technical ideas are expressed can have considerable bearing on the size of the clutter."

Ghostwriting also reduces the pride of authorship. A West Coast airplane company points out that writing for publication furthers an engineer's reputation; the realization that another man has done much of the work diminishes this pride.

One or two companies point out the possibility that technical editors, who are not well-versed in technical

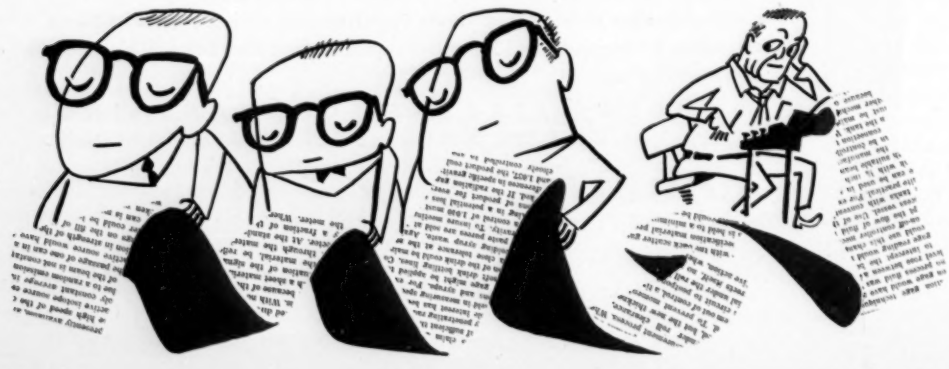


matters, may make embarrassing mistakes and bring possible loss of sales to the company.

Publications Committees

How can companies avoid such errors and still make use of technical editors? One way, which over 54 per cent of R/E's respondents are employing, is through the use of publications committees to review the literary efforts of engineers. Men from various departments are represented on these committees. They are responsible for assigning articles and reviewing manuscripts. They meet from time to time, sometimes once a month, and bring to each manuscript the accumulated experience of their various backgrounds.

These publications committees are popular for three reasons. One is that they diminish the chance of errors. Just as important, they stimulate interest in writing by providing an immediate audience for the author. Also, because he knows that the manuscript will go the rounds right away, the author tends to polish his work beforehand. Finally, as one highly placed official in a chemical company points out, "Committees are a necessity in a company like ours, where the engineers are producing plenty of articles of various levels of competence. The committees provide a method of fairly assessing the articles for value and determining priorities—which articles should be published first and which are of secondary importance." *(Continued on page 38)*



Publications committees provide an immediate audience for the author

Transistors and Micro-miniaturization

ROBERT COLMAN, Director
Research Products Associates

The 1957 IRE Convention, held in New York's Coliseum, was the biggest electronic convention in history. Yet it was dominated by one of the smallest components of modern technology—the transistor.

What have been the major electronic advances in the past year? Essentially, the IRE show revealed that the year's major advances have been based on the taming of the transistor.

Small Packages

Prominent among these advances were the drives toward microminiaturization and something approaching total reliability. The electronic package has been taken into smaller and smaller regions, chiefly by using semiconductors instead of tubes.

North American Aviation's J. R. Moore, called micro-miniaturization "the ultimate technique" because it promises total automation. It makes automated machinery possible and makes the components small enough for the machines to handle conveniently. A big bonus of micro-miniaturization is cost savings. To the military this means more defense per dollar, for if one can make a missile half the size of its predecessor and still get the same results, he needs only half as many planes to carry the weapons, half as many men to man them, half the equipment and half the logistical support.

The second major theme of the convention was a variety of new transistor applications. These new uses were the keys to breakthroughs in several knotty technological problems. For one example, prime DC battery currents can now be converted to higher DC levels without the need for vibrators and other unreliable mechanical devices that break down long before the electronic package they service. Universal Atomics of New York City, Celco, Bendix, and Power Sources, Inc., displayed transistorized power converters that use no moving parts. The results are power packages of enormously increased reliability.

The IRE show previewed a number of other transistor applications:

Telemetering

Transistors have made possible new performance highs in telemetering. Used in measuring missile performance, transistors overcome extreme environmental conditions faced by airborne equipment. In the past, directly-connected amplifiers encountered serious difficulties because their vacuum tubes suffered thermionic drift. Silicon transistors greatly reduced that problem at no cost to band width or high input.

Counters

High-speed counters, frequency and interval meters have, through the application of transistors, been made more reliable and accurate. Formerly, the power supplies produced accuracy-spoiling power variations. The transistor has largely eliminated this problem.

Computers

One ingenious development in computer systems is AVCO Electronics Research Laboratory's packaged computer building-blocks. These are modular basic circuit elements that can be combined in any degree of complexity to satisfy the particular demands of a laboratory. The need to buy a general purpose, packaged computer is thereby avoided. Transistors and diodes are the hearts of the modules.

IBM and Univac experts discussed using computers for designing ultra-reliable circuits. Special digital computers take over the trial-and-error tedium and tremendously accelerate test rate. They check any number of circuit configurations, vary them, and concurrently spot possible failures.

But there are limits to computer horizons. For the present, the limitations are human ones. Further use of computers, and fuller use of those we now have, will require engineers more thoroughly trained in operational mathematics. Remarks at the end of one session on computers indicated the concern many engineers are even now feeling in the matter. A machine, they insist, cannot do an engineer's creative mathematical work. It can only solve details of the problem. Having the engineer take his problem to a mathematician for programming won't work because the mathematician lacks specific engineering knowledge. The only permanent solution is to properly train engineers in mathematics.

Other Developments

The show had a bewildering number and variety of exhibits.

- R.C.A. exhibited an electronic light-amplifier panel that increases visible brightness of a projected light area a thousand times, and converts X-rays to bright visible light.
- Douglas Aircraft displayed a system of X-ray-sensitive phosphor, matched with a sensitive TV pick-up monitoring device that allows fluoroscopic examination of the body. It reduces X-ray exposure time to 1/120-second and, by application of the Memo-scope principle, retains the image for a minute or more for leisurely and safe examination.

Motorola, Inc., featured an electrostatic character writing tube that can be enclosed in the same neck with an electron gun to form a combination capable of simultaneously displaying radar echoes and identifying letters or figures on the same 19" screen.

Transistors again, of the power-type; their application centers about high operating temperatures, aircraft and missile applications.—END

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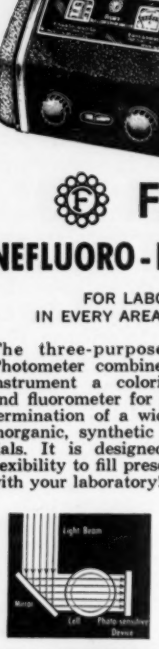

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CIRCLE 65 ON PAGE 48 FOR MORE INFORMATION

Soviet Syllabus—
(Continued from page 14)

Solution of simple trigonometrical functions. Theorems concerning sines, cosines and areas of a general triangle. Application of trigonometry to geometrical problem solving.

IV. PHYSICS

1. Mechanics — Rector analysis. Conditions of equilibrium for a body and simple mechanisms. Centre of gravity. Uniform rectilinear motion including velocity and equations. Graphs of trajectory of motion with respect to time. Newton's laws. Weight and mass of a body. Density and systems of units. C.G.S. system; relation of force to mass. Acceleration of free-falling bodies. Air resistance. Third law of motion. Kinetic and potential energy. Work. Conservation of energy in mechanics. Uniform circular motion. Linear and angular velocity. Centripetal acceleration. Gravity. Elastic bodies. Dynamometers.

2. Oscillations and Waves: Sound — Oscillatory motion. Periods. Amplitude. Relation between period and frequency. Formula for period of oscillation of a pendulum. Mechanical resonance. Transverse and longitudinal waves. Velocity of wave propagation. Wavelength. Relation between wavelength, wave velocity and frequency. Wave motion in air. Sound velocity and reflection. Acoustical resonance.

3. Liquids and Gases.— Pressure. Pascal's law. Hydraulic pressure. Monogeneous liquids and mixtures. Atmospheric pressure. Torricelli's experiment. Barometry. Archimedes' law for liquids and gases. Aerometers. Evaporation. Motion of gases and liquids. Work of N. E. Joukowski. Boyle's law. Graphical representation. Liquid and metallic manometers. Pumps.

4. Basis of the Molecular-Kinetic Theory of Matter— The molecular-kinetic theory. Experimental basis. Brownian motion. Diffusion in, and motion of molecules of gases, liquids and solids. Mass, dimension, and interaction of molecules.

5. Heat — Thermometry. Clausius scale. Coefficients of linear and cubic expansion. Expansion of water and gases. Gay-Lussac. Formula for resulting law of Boyle-Mariotte-Gay-Lussac. Absolute zero temperature. Heat; units. Latent heat of fusion. Experimental determination of specific heat. Convection in gases and liquids. Thermal conductivity. Fusion. Experimental determination of latent heat. Transpiration. Ebullition. Boiling-point and pressure. Experimental determination of latent heat of vaporization. Saturated and superheated vapours of a liquid. Relation between saturation pressure and temperature. Humidity and hygrometry. Compression of gases. Lomonossov on the nature of heat. Mechanical equivalent of heat.

6. Electricity — kinds. Interaction of electric charges. Coulomb's law. Electrostatic and practical units of charge. Design of electroscope. Distribution of electricity on surface of conductor. Influence charging. Electric field of a charge. Field intensity. Simple cased calculation. Potential. Capacitance. Condensers. Current. Potential difference at ends of a conductor. Ohm's law. Resistivity. Resistance and temperature. Rheostats. Work and power of a current. Electrolysis. Electric current in gases. Magnetic field of primary current in coils. Interactions of magnetic field with current. Intensity of magnetic field and magnetic flux. Alternating current. Period, frequency and phase. Rectification. Transformers. Electric power stations. Transmission and distribution of electrical energy. Success of electrification in the Soviet Union. Electromagnetism. Oscillation contours. Invention of radio by A. S. Popov. Radiotelegraphy. Amplitude modulation. Thermionic tube as an amplifier. Cathode-ray tube. Principles of radiolocation.

7. Optics—Sources, velocity and propagation of light. Michelson. Unit of illumination. Reflection and refrac-

(Continued on page 37)

(Continued from page 14)

trained for the jobs to which they are later assigned; jobs that we fill by under-rating our engineering graduates or with on-the-job-trainees.

Technicums and other secondary training schools insure Russia a more complete utilization of her manpower resources.

Curricula

Consistent with this economical use of manpower is Russia's use of man-hours. She has defined her needs closely and designed her syllabi around them. Her most pressing need is for skilled production engineers, for specialists in narrow fields. Her engineering training reflects that need. The training of Soviet chemists, compared with our own, has the Russian chemistry major spending at least a third more time on chemistry subjects than his American counterpart. The Soviet student is required to learn more about other sciences such as analytical geometry, calculus, physics, thermodynamics, mechanics, etc. All these are a part of his curriculum and replace American courses in general education, liberal arts, and social sciences.

Some cooperative training programs occur in our training of engineers. But they are the exception. The Soviet Union, in contrast, requires industrial practice in all engineering programs. Taking industrial practice together with laboratory time, applied training in the Soviet curriculum accounts for 72 percent of engineering instruction.

Another aspect of the Russian emphasis on the practical is the narrowness of their specialization. Standard practices and procedures, and administrative-managerial problems are stressed. In the U.S., early specialization and extensive technological training is usually regarded as an obstacle to creative engineering talent. But this very narrowness is desirable in Russia because most engineers are called upon to work in production jobs.

Administration

Five-year plans and centralized authority account for much of Soviet industrial growth. The same is true of Soviet higher education. All advanced schools, and their curricula,

(Continued on next page)

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KINNEY high capacity pumping system shown at left.
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"The outfit with the 'know how' has the answers" . . . and this is doubly true in Vacuum technology! KINNEY High Vacuum Pumps provided the answers "away back when" and you can practically chart the significant advances in Vacuum processing by the developments contributed to the art by KINNEY engineering.

The KINNEY oil sealed rotating plunger Pump, producing pressures down to 0.2 micron, continues to be the outstanding Pump of its kind in the world. The KINNEY Mechanical Booster Pump, introduced but four years ago, is contributing important advantages in securing clean, dry Vacuum at even lower pressures.

Now KINNEY offers the metallurgist new tools for production and research... complete High Vacuum Systems – Evaporators, Furnaces, Drying Ovens and Packaged Pumping Systems. And for the Metals industry – Complete High Vacuum Systems for Melting, Degassing, Casting, Refining and Heat Treatment.

Yes, "for new developments in Vacuum Metallurgical Equipment" get the answers – *based on experience* – from KINNEY.

WRITE: for Catalog No. 425, fully describing KINNEY High Vacuum Pumps, or for detailed information on your specific problem.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
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Kindly send me catalog No. 425 ☐
Also send further information on your complete Vacuum equipment ☐

Name_____
Company_____
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City_____ Zone____ State_____

CIRCLE 66 ON PAGE 48 FOR MORE INFORMATION

NEW CALIDYNE 177 SHAKER SYSTEMS

The Model 177 is one of a new series of "wide-band" shakers designed for higher frequency operation and lower input requirements. It is the Basic Unit for five completely integrated CALIDYNE Vibration Test Systems. Oscillatory linear forces up to 5000 lbs. are generated and precisely controlled over wide ranges for vibration research and test of products up to 411 lbs. maximum load. Any of these five Vibration Test Systems using this New Model CALIDYNE 177 Shaker will enable you to:

1. Discover effects of "brute force" shaking on your assemblies and determine their ability to withstand vibrations far beyond those of normal operation.
2. Provide factual vibration data essential in determining mode shape, frequency and damping characteristics.
3. Determine results of fatigue testing at extremely high stresses and deflections.

CALIDYNE VIBRATION TEST SYSTEMS USING NEW MODEL 177 SHAKER

System Number		Type of Vibration	Force Output	Power Supply	Frequency Range	Maximum Load	
						10 g.	20 g.
1	177/80	Sinusoidal	3500 lbs.	Electronic	5-2500 cps.	261 lbs.	86 lbs.
2	177/180	Sinusoidal	5000 lbs.	Rotary	5-2000 cps.	411 lbs.	161 lbs.
3	177/186	Sinusoidal	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.
4	177/190	Random or Sinusoidal†	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.
5	177/190	Random†	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.

†*This system will perform with Random, Sinusoidal, Tape or Mixed Inputs.*

A separate Bulletin 17700 details the specifications, performance data, basic components and accessories of the new Model 177 CALIDYNE Shaker and its five Shaker Systems. For engineering counsel in applying Controlled Vibration to your research and testing, call us here at CALIDYNE — WInchester (Boston) 6-3810.

THE CALIDYNE COMPANY

120 CROSS STREET, WINCHESTER, MASSACHUSETTS

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Ridgewood, N. J. (Gilbert 4-1400)
Syosset, L. I., N. Y. (Walnut 1-3095)
Philadelphia, Pa. (Walnut 2-3270)

M. P. Odell Company
Westlake, Ohio (Trinity 1-8000)
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CANADA

Measurement Engineering Ltd.
Arnprior, Ont. (Phone 400)
Burlington, Ont. (Nelson 4-5686)

EXPORT

Rocke International Corp.
13 East 40th Street, N. Y. 16, N. Y.
(Murray Hill 9-0200)

CIRCLE 67 ON PAGE 48 FOR MORE INFORMATION

(Continued from preceding page)

are under the penultimate control of the Ministry of Higher Education. That ministry is a switchboard from which educational activities throughout the USSR can be coordinated. The ultimate determination of what shall be done falls within the overlapping provinces of the Central Planning Commission, the Party, the MVD, and the financial arms of the government. Thus, if a shortage of metallurgists is anticipated, the entire machinery of persuasion and compulsion can be brought to bear to supply the need. Student stipends may be raised, better living quarters arranged, other benefits conceded. The whole adjustment of industrial demand and educational supply can be preserved by this centralized coordination.

• • •

These then are some of the devices Russia has used to mobilize her educational establishment: she has closed avenues of social rise so that a career in education or science or engineering is almost incumbent on the ambitious man or woman; she has provided not only free schools, but also stipends and bonuses for students; she has accorded critical areas of education priorities for new facilities; she has bestowed monetary benefits and prestige upon scientists and teachers; and, very significantly, she has used her technicums to train to their uttermost capacities as many technicians as possible to support her more highly educated technical personnel.

Soviet and U.S. Premises

Russian educational philosophy is such that it allows this kind of manipulation. It has three major premises.

1. The advancement of science and technology is best promoted through central planning of education and research.

2. Scientific and educational efforts are primarily a means for the advancement of the overall interests of the nation.

3. The basic truths of human life, of nature and the universe, and of social, political, and economic, reality have been discovered and indubitably proclaimed.

Thus, the task of the teacher and the scholar is to demonstrate and to apply these truths rather than to question them and seek alternatives.*

These principles, and the philosophy of Marx and Lenin from which they spring, account for the differences in purpose and form between Soviet and Western education. The purpose of both is to produce a skilled person. The purpose of the skilled person, in turn, is to serve society. But at this point the purposes diverge, at least in emphasis. The Western purpose emphasizes the development and welfare of the individual for his own sake; and a concommitant of his self-development is his responsibility as a citizen to the state. The Russian emphasis is upon development of the individual as a social resource: the end of education is not individual benefit but state benefit. The Western attitude necessarily results in a certain diffuseness of effort and even waste—since the end is not finally determined by much more than the individual's desires, and these have all the variety and vagary of individual tastes and preferences. The Soviet attitude results in a sharp and purposeful focus where curricula are determined by the state in accordance with its desires and needs and the individual must conform to this simpler and stronger pattern.

But besides this difference between American and Russian educational philosophies, there is another strong contrast. Many of the Soviet solutions are available to us without alteration of our principles. We can pay teachers better salaries and accord them social status commensurate with their importance; we can increase subsidies to education; we can make science more attractive to young people, and we can better develop their talents. The contrast subsists not so much in what the Soviet can do and we can't; but in that they are doing what they can.

*H. Berman, *Columbia Law Review*, May '54

Soviet Syllabus—*(concluded)*

tion. Concave and convex lenses. Lens formulae. Photographic apparatus. Microscope and telescope. Prisms. Spectra. Absorption spectra. Fraunhofer lines. Wave nature of light. Interference. Photoelectric effect. P. N. Lebedev on magnitude of light pressure.

8. Atomic Structure—Phenomena verifying the complex structure of the atom. Means of observing particles. Atomic structure. Radiation and absorption of energy by uranium atom. Composition of the atomic nucleus. Chain reactions.

V. CHEMISTRY

Physical and chemical phenomena. Mixtures and compounds. Chemical reactions. Exothermic and endothermic reactions. Simple and complex matter. Elements. Allotropy. Metals and non-metals. The basic position of the atomic-molecular scientist M. V. Lomonossov as founder of atomic-molecular study. Atomic and molecular weight. Gramme-atom. Gramme-molecule. Lomonossov's laws of conservation of weight. Valency. Chemical formulae and equations. Selection of coefficients for given starting and end products for simple reactions. Solutions. Graphical representation of solubility in gases, liquids and solids. Oxides, bases, acids and sales. Electrolytic dissociation. Electrolytes and non-electrolytes. D. I. Mendeleev, the periodic law. Radioactivity and radioactive decay. Basic knowledge of atomic structure. Hydrogen. The halogens and chlorine. Chlorine compounds. Oxygen. Sulphur. Hydrogen sulphide. Sulphur dioxide. Nitrogen. Air as a mixture of gases. Phosphorus. White and black phosphorus and natural compounds. Carbon, diamond, graphite and coal as allotropic modifications of the basic element. Theory of A. M. Butlerov of the composition of chemical compounds. Benzole. Hydrocarbon spirits. Chromium. Sodium. Calcium. Aluminum. Iron and steel.

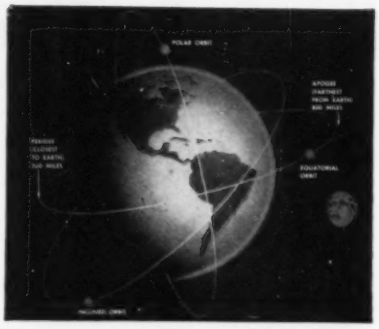


Illustration courtesy of *Popular Science Monthly*.

New stability for satellite tracker

Power resistors win out over "precision" resistors for low drift plus high overload capacity

A few millivolts power-supply drift can mean a large range or angle error in tracking the U. S. Navy's satellite missile—built for the International Geophysical Year.

It's for this reason that voltage regulated power supplies for the tracking equipment must be as stable and as drift-free as the state of the art permits, over a very wide range of operating conditions.

That, in brief, is the problem that faced engineers at Power Designs Inc., Richmond Hill, N. Y., builders of regulated power supplies for the satellite tracking equipment.

To make the problem really tough, however, maximum reliability required that failure of any component not damage any other component. Certain vacuum tube failures, for example, subjected ordinary precision resistors to an 8 to 10 times overload. The resistors charred, opened up. Some even blew up, literally!

Engineers at Power Designs got together with Ward Leonard engineers and came up with the answer: A special Ward Leonard Vitrohm resistor that had all the drift-free stability required plus the overload capacity that makes Vitrohm resistors a favorite among designers. More economical, too.

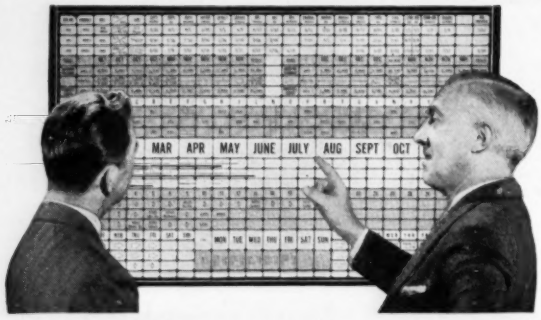
This, of course, is added testimony to the facts we've known all along about Ward Leonard Vitrohm resistors. And, it shows the cooperation you can expect when you bring your special problems to Ward Leonard's application department.

We predict, too, that you'll be hearing more about these special high-stability Ward Leonard Vitrohm resistors. Particularly if you're concerned with analog or digital computers, acquisition or tracking equipment, instrumentation or other application requiring the utmost in stability plus high overload insurance. For more data *now* write: Ward Leonard Electric Co., 12 South Street, Mount Vernon, N. Y. (In Canada: Ward Leonard of Canada Ltd., Toronto.) 7.2

LIVE BETTER...*Electrically*

FOR MORE DATA CIRCLE 68 ON PAGE 48

How To Get Things Done



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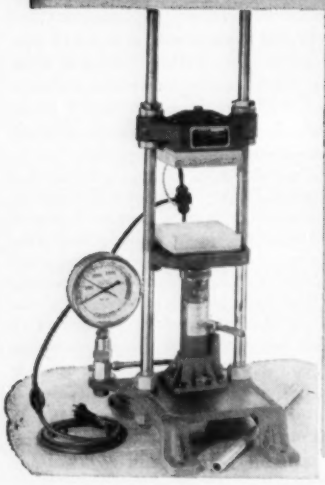
The CARVER LABORATORY PRESS



...Solutions for Pressing Problems

Accurately controlled pressures to 20,000 lbs.; 6-inch gauge mounted on base. Carver Standard Accessories include Electric or Steam Hot Plates, Carver Test Cylinders, Swivel Bearing Plates, Cage Equipment. Available from stock. Write for catalog.

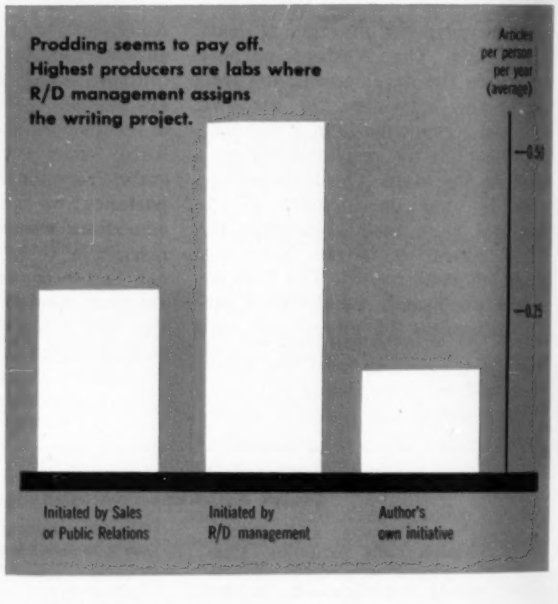
FRED S. CARVER INC.
HYDRAULIC EQUIPMENT
1 CHATHAM ROAD, SUMMIT, N. J.

CIRCLE 71 ON PAGE 48 FOR MORE INFORMATION

Authorship & Company Policy

(Continued from page 32)

On the negative side are the standard criticisms of committee management which arise from time to time. The members of publication committees are frequently not familiar enough with the subject of the manuscript to be qualified to review it. Sometimes the comments on the margins of the manuscript are a deterrent rather than an encouragement to further writing. In addition, frequently no one takes responsibility for seeing that the publications are mailed out to magazines. When a technical writer is available, there is always one individual to ride herd on articles and see that a specified number are distributed. In committees, with each of the members too busy to give it his full time, this activity is often ignored.


Prodding seems to pay off.
Highest producers are labs where R/D management assigns the writing project.
Articles per person per year (average)
0.50
0.25
Initiated by Sales or Public Relations
Initiated by R/D management
Author's own initiative

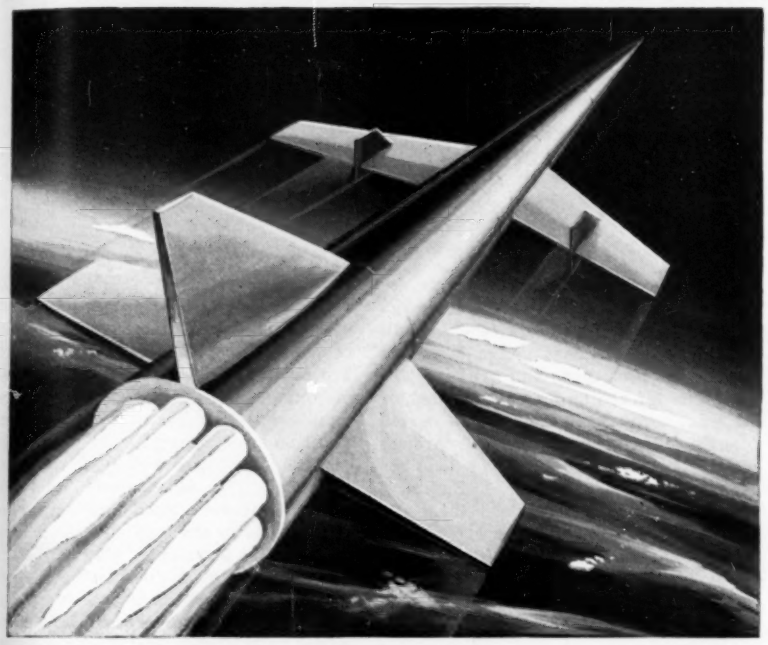
How About the Time Element?

Seventy-five per cent of R/E's respondents agreed that time is one of the main obstacles to the production of scientific literature. Handy & Harmon reports, "The problem is to get the job done. The result is that the author works on the report during and after hours." And J. Bennett Hill, Director, the R & D Department of the Sun Oil Company in Philadelphia says, "Though it's accepted that the engineer may write on company time, actually most of this work is done on his own time."

A great number of companies, 51 per cent, make allowance for this lack of time by permitting engineers to do some of their writing on company time unless a special project intervenes. The truth is, however, that special projects arise so often in most labs that engineers have little if any time to write during office hours.

Quality the Main Concern

Perhaps the best appraisal of the scientific literature being produced in America today was made by Ralph Phelps, Director of the Engineering Society Library, who commented, "Measuring writing in terms of quantity is pretty meaningless. The important thing is that scientific literature be written with a view toward teaching and informing, not just to place one's paper before a meeting." END



Which of these PROBLEMS fit your fields of interest in ROCKETS?

Bell Aircraft long a leader in liquid rocket development, produces aircraft and missile propulsion systems embodying the most advanced design concepts. Major efforts of the newly organized Rocket Division are directed toward the design and development of power plants, including turbine pumps, control valves, gas generators, pressurization systems and tanks.

Some of the problems which are under extensive investigation by the Rocket Division are:

1. Devise a method to study the formulation of propellant jets and droplets on injection and follow their behavior during the phases of mixing atomization, evaporation, and combustion.

2. Determine by means of specially designed apparatus, the coefficients of heat transfer to a liquid in the non-boiling, nucleate boiling, and film boiling regimes as functions of pressure, velocity, and bulk temperature.

3. Conduct an analysis of each component entailing fluid pressure losses, speed of operation, expected variations due to minute flow change and their effects on the component operation.

4. Plan testing and data analysis for liquid rocket engine design and development to overcome problems involving extreme temperature operation, turbine speed control, reliability, serviceability and maintenance.

If your qualifications place you in a position to help solve these challenging problems...or if you are now limited in the scope of your opportunity and would like to participate in any of Bell's widely diversified activities in other fields, write today: Manager, Technical Employment, Department M10, Weapons Systems Division.

BELL AIRCRAFT CORPORATION, P. O. Box One, Buffalo 5, New York.

BELL Aircraft corp.

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- Aerodynamicists
- Aeronautical Engineers
- Automatic Control Designers
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- Design Checkers
- Development Engineers
- Digital Computer Development Engrs.
- Dynamic Engineers
- Electronic Engineers
- Electronic Standards Engineers
- Engineering Computors
- Environmental Specialists
- Field Test Engineers
- Flight Test Engineers
- Flight Test Programmers
- Fuel Injection Specialists
- Gear Designers
- Guidance Engineers
- Gyro Specialists
- Heat Transfer Engineers
- Hydraulic Engineers
- IBM Programmers
- Instrumentation Specialists
- Laboratory Test Engineers
- Magnetic Amplifier Specialists
- Mathematical Analysts
- Mechanical Engineers
- Microwave Engineers
- Miniturization Engineers
- Nuclear Physicists
- Operations Analysts
- Physicists
- Power Plant Designers
- Pressure Vessel Designers
- Project Engineers
- Publication Engineers
- Radar Systems Engineers
- Reactor Designers
- Reliability Engineers
- Rocket Test Engineers
- Servo Systems Engineers
- Servo Valve Engineers
- Statisticians
- Stress Engineers
- Structures Engineers
- Specification Writers
- Technical Writers
- Test Equipment Engineers
- Transformer Design Specialists
- Transistor Application Engineers
- Thermodynamic Engineers
- Telemetering Engineers
- Turbine Pump Designers
- Vibration & Flutter Analysts
- Weapons Systems Engineers
- Wave Guide Development Engineers
- Weights Engineers

LABORATORY EQUIPMENT

Ionimeter

The constantly higher precision now being demanded in many laboratory and production practices, necessitates the use of water of known ionic purity. The problem of quickly and economically determining the ionic purity of water has now been solved with the introduction of this new testing device called the Crystalab IONIMETER Model CT-21. It comes equipped with D'Arsonval meter with direct reading dial graduated 0 to 50 in parts per million as NaCl. This scale range converted into electrical resistance is 5,000,000 to 0 ohms. Crystal Research Lab., Inc., 29 Allyn St., Hartford 4, Conn.

CIRCLE 40 ON PAGE 48 FOR MORE INFORMATION

Magnet Wire R/D Kit

This Teflon Magnet Wire Kit was designed specifically for use in Research and Development projects where small quantities of different gauge sizes are needed for prototypes and experimentation. The kit contains an assortment of 12 miniature spools of Teflon coated Magnet Wire in gauge sizes 20 through 42 AWG. This wire conforms to Type III, MIL-W-19583 (NAVY) Specifications. Tensolite Specialties, Inc., 198 Main St., Tarrytown, N. Y.

CIRCLE 41 ON PAGE 48 FOR MORE INFORMATION

Ultra-High-Vacuum Valve

This new laboratory ultra-high vacuum valve for handling pressures of 10^{-10}mm Hg and lower is useful in vacuum systems where non-contamination and the ability to bake out are of the highest importance. Effective conductance of the valve for nitrogen is only 1 x 10^{-11} liter per second. The VAU-25 valve seals a vacuum system from a diffusion pump without the contamination and inconvenience of a glass seal-off. It also handles very pure gases, such as noble gases. The assembly is a Monel cup sealed off by a flexible Monel diaphragm which can move 0.1 inch. Opening into the Monel cup are two ¼-inch copper vacuum leads. Rochester Div., Consolidated Electrodynamics Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.

CIRCLE 42 ON PAGE 48 FOR MORE INFORMATION

L-Band Dummy Load

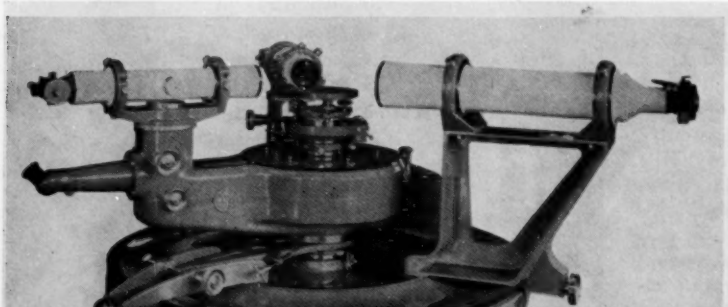
This dummy load features a direct indicating calorimetric watt-meter. The load elements are two tapered fluid elements of molded fiberglass construction which are centered inside of a four foot long section of aluminum waveguide. A remote heat-exchanger unit pumps a constant volume of lossy liquid through the tapered fiberglass elements to absorb the heat. The differential liquid temperature between input and output flow connections to the load element is measured by a thermopile element, and a remote meter reads directly the kilowatts of energy absorbed. The unit operates in a frequency range from 1150 megacycles to 1750 megacycles with a voltage standing wave ratio of less than 1.15 and is rated at 1500 watts maximum average power and 5 megawatts peak pulse power. WacLine, Inc., 35 S. St. Clair St., Dayton 2, Ohio.

CIRCLE 44 ON PAGE 48 FOR MORE INFORMATION

Spectrophotometer

For the laboratory with a limited budget this table top infrared recording spectrophotometer is useful for infrared analysis. It measures 47 x 30" and provides for differential analysis merely by adding a fixed slit mechanism, a variable scan drive and an AC basis. Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.

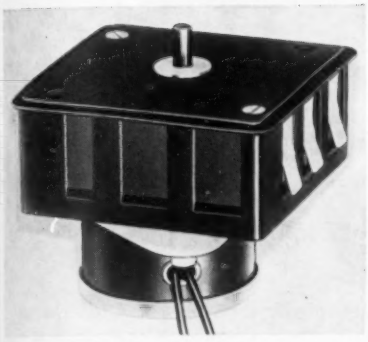
CIRCLE 45 ON PAGE 48 FOR MORE INFORMATION



Precision Spectrometer

This spectrometer offers angles and circular spacing up to .1 second direct reading to test precise angles of prism faces, gage block combinations and instrument assemblies. One accurately divided circle reads both table and telescope positions. The work piece or telescope can be rotated independently of each other. The circle reading corrects centering errors; it is direct to .1 second. The spectrometer carries a collimator on a pillar, which can be set to any desired position around the ring on the base. Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.

CIRCLE 43 ON PAGE 48 FOR MORE INFORMATION



Interval Timer

This new Interval Timer can be two-hole mounted or one-hole center mounted. A durable, molded bakelite case houses one or two SPDT or SPST open blade switches rated at 30 amps, 115 v AC resistive and 1/3 h.p. at 115v AC. The permanent magnet synchronous motor drives precision cut cams which actuate the 30 amp switches at full scale intervals ranging in duration from 45 sec. to 6 days. Shorter than 45 sec. ranges are available with lower contact ratings. Designed for high volume production, Type 271 Interval Timer provides accurate timing and reliable operation at an economy price. For use on all standard voltages, 60 and 50 cycles, and a wide selection of special voltages, Type 271 is designed for U. L. approval. Cramer Controls Corp., Centerbrook, Conn.

CIRCLE 46 ON PAGE 48 FOR MORE INFORMATION

Pulse Generator

The insides of this pulse generator are easily accessible. The circuitry provides fast rise time pulses at high repetition rates. Controls for this improved version of the Model 2125A provide excellent resolution, utilizing multiple-decade ranges for pulse spacing, delay and width. Repetition rates from 10CPS to 100 KC, variable advance or delay operation 0 to 100 usec, variable pulse width from less than 0.1 to 100 usec and variable amplitude low impedance output are provided. Snap-off top and bottom plates provide complete accessibility and overhanging light shield minimizes instrument panel glare. Electro-Pulse, Inc., 1181 Major St., Culver City, Calif.

CIRCLE 47 ON PAGE 48 FOR MORE INFORMATION

Your Tektronix Field Engineer as an

ORDERING AID

Assisting with all phases of the ordering process is another of his many helpful functions.

THE CORRECT TOOL

There are many types of oscilloscopes, each designed for a specific application area . . . from the broad general-purpose oscilloscope to the highly specialized instrument. Your Tektronix Field Engineer can help you make the best possible investment by recommending the oscilloscope best suited to your present and future needs. He will be happy to back up his recommendation with an actual demonstration of the instrument in your application. But he will not hesitate to recommend some other method of attacking the problem if it appears to meet your requirements more efficiently. Try him. A no-pressure consultation with him can help you select the correct tool for your work.

PURCHASING DETAILS

If you are a Purchasing Agent or Buyer, you may occasionally need information on prices, terms, shipping estimates, and best method of transportation on instruments and parts. Although your Tektronix Field Engineer does not provide you with cigars or gadgets, he will gladly furnish whatever information you need to help ease your work. And he won't bother you with technical specifications unless you ask for them. He knows that you know what's going on in your Company, and will appreciate your help in steering him around.

FOLLOW-UP

The value of your oscilloscope is highest when you are able to realize its full potential. If your choice is a Tektronix Oscilloscope, your Tektronix Field Engineer is available to help you achieve maximum utility. Look to him for any kind of assistance with any Tektronix Instrument...any time.

Tektronix Field Offices: Albertson, Long Island, N. Y. — Albuquerque, N. M. — Baltimore, Md. — Bronxville, N. Y. — Cleveland, Ohio — Dallas, Texas — Dayton, Ohio — Elmwood Park, Ill. — Houston, Texas — Los Angeles, Calif. — Menlo Park, Calif. — Minneapolis, Minn. — Mission, Kansas — Newtonville, Mass. — Philadelphia, Pa. — Phoenix, Ariz. — Syracuse, N. Y. — Union, N. J. — Willowdale, Toronto, Ontario.

Tektronix Engineering Representatives: Bivins & Caldwell, High Point, N. C. and Atlanta, Ga. — Hawthorne Electronics, Portland, Ore. and Seattle, Wn. — Hytronic Measurement Associates, Denver, Colo. — Arthur Lynch & Associates, Fort Myers, Fla.

Tektronix is represented in seventeen overseas countries by qualified engineering organizations.

TEKTRONIX, INC., P. O. BOX 831, PORTLAND 7, ORE.

CIRCLE 72 ON PAGE 48 FOR MORE INFORMATION

Photo courtesy of *Aviation Age*

New control for jets ...and industry!

Precise control of every operating pressure is a must for the jet engines that power our modern military aircraft.

To make matters tough for the design engineer, this control must often be automatic or semi-automatic, function reliably under many diverse conditions. *And, last but not least, the pressure sensing element must often be as linear as it's possible to make it.*

Engineers at the Hamilton Standard Division of United Aircraft selected Bristol's capsular pressure sensing elements for the fuel control systems soon to go into planes like the Navy F8U Crusader, above.

For Bristol has built up a backlog of 67 years experience in manufacturing pressure-sensing elements for use in our own Bristol instruments under the most diverse operating conditions.

We've found out how to build them to take punishment—for example, they'll take 200,000 flexings at 30 cpm with no more than 1% change in characteristics. And we believe the linearity of Bristol elements can't be equalled anywhere in standard units.

Because of expansion of our facilities, Bristol pressure sensing elements are now available to industry. They come in a wide variety of stock characteristics between the extremes listed below. Ask us for Bulletin AV 2001. The Bristol Company, 146 Bristol Road, Waterbury 20, Connecticut. 6.68

RANGE OF CHARACTERISTICS
(Stock Capsules)

Characteristic	Range Min.	Range Max.
Outer diameter (in.)	1 5/16	2 11/32
Effective area (square in.)	0.40	1.67
Travel (in./psi)	0.0004	0.015
Pressure span (psi)		
• Expansion	2	100
• Compression	2	100
Deviation from linearity (max %)	1/4	1
Hysteresis effect (max %)	1/4	1/4
Allowable overpressure (max % to maintain linearity)	20	20
Temperature range (normal)	—65F to 300F	—65F to 300F
Temperature for 2% travel change	550F	550F
Spring rate (p/in., ±10%)	24	1875

BRISTOL

Automatic Controls • Recorders • Telemeters
Socket Screws • Choppers and High-Speed Relays
Aircraft Pressure-Operated Devices

CIRCLE 73 ON PAGE 48 FOR MORE INFORMATION

r/d contracts

Experimental Facility OK'd

The Atomic Energy Commission has filed notice of the proposed issuance to Babcock & Wilcox Company of New York of a license to operate its critical experiments facility near Lynchburg, Virginia.

The Babcock & Wilcox Company applied in October 1955, for a permit to construct the facility on a 520-acre tract about 3½ miles east of Lynchburg, where the company's fuel element fabrication plant is located. Based on a review of the application and its amendments, including the company's safeguards reports, the Commission concluded that there was reasonable assurance that the facility could be operated at the proposed site without undue risk to the health and safety of the public. The construction permit was granted in December 1955.

A critical assembly differs from a reactor in that the arrangement of the fuel assembly and other components is not permanent, but may be re-arranged without difficulty. The chain reaction is maintained at or near zero power, and little radiation is emitted. Assemblies of this sort are used to study the behavior of special nuclear materials at various degrees of enrichment and in different shapes.

The license to Babcock & Wilcox provides that the company must submit each planned group of experiments to the Commission for a safety evaluation by the staff before the tests are conducted. The license contains authorization to perform critical experiments which are related to the design of the reactor for the nuclear power plant now under construction by Consolidated Edison Company.

Nuclear Training Grants

This month the Atomic Energy Commission approved grants of $1,193,450 to 15 American universities for equipping laboratories. The laboratories will be used for training nuclear scientists and engineers as part of the Commission's policy of helping solve the manpower shortage in the atomic energy field. The Commission also loaned the universities and colleges material such as uranium metal and neutron sources.

The AEC has received more than 40 proposals for grants since the policy was announced last September. Additional announcements of awards are planned for the near future. The largest grant—$216,950 to the University of Puerto Rico—is for the establishment of a nuclear training center as part of the Atoms-for-Peace Program.

Sea Water Lab Set Up

A new marine testing laboratory has been set up at the Harbor Island, N.C. station of the International Nickel Co., by Griscom-Russell Co., Massilon, Ohio. Purpose of the new facility is to obtain accurate and complete data on heat transfer and evaporator equipment and materials under actual sea-water conditions. Data from this lab are expected to aid in a recently awarded R/D contract with the Department of the Interior, Office of Saline Water Research, in the application of low-thermal-difference distillation.

Nuclear Center for Cleveland

The Atomic Energy Commission has authorized The Austin Company of Cleveland to proceed with preliminary designs for a nuclear center which is being planned under the joint sponsorship of Case Institute and industrial firms interested in types of research which require a high flux engineering test reactor. The other participants include: Cleveland Electric Illuminating Co., Republic Steel, Shenley Industries, Inc., Standard Oil Company of Ohio, and Thompson Products, Inc.

Pool-Type Reactor to Germany

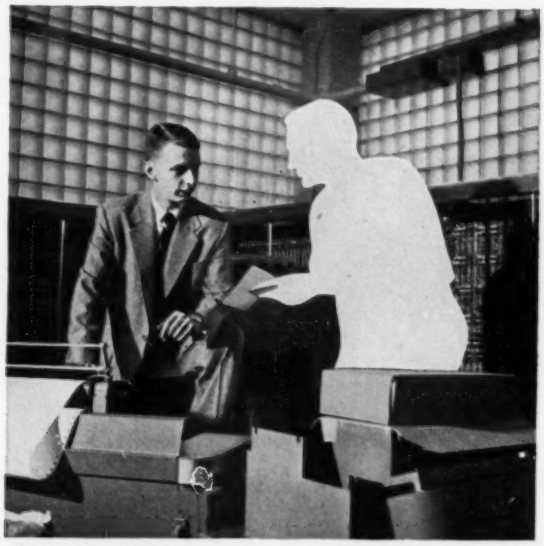
The Atomic Energy Commission has filed notice of the proposed issuance of a license to AMF Atomics, Inc., of New York for the export of a research reactor to West Germany. The reactor, a 1-megawatt pool-type research facility, is to be shipped to the Land Bayern, Federal Republic of Germany, for erection at the Laboratorium fuer Techniche Physik de Technischen Hochschule Muenchen near Munich.

SIR to be Shut Down

The Department of Defense does not plan to install sodium-cooled reactor propulsion systems, such as were used in the Sea Wolf, in any more naval vessels. The Atomic Energy Commission will shut down the prototype submarine intermediate reactor (SIR) which was developed at GE's Knolls atomic power laboratory and has been operating experimentally since May, 1955. The AEC recently assigned a new project to the laboratory: a pressurized water nuclear propulsion system for a surface vessel of the destroyer type. In addition, the laboratory will develop a pressurized water power plant of advanced design for the submarine Triton.

IBM GROWTH promoted these men

Research Engineer: Before his recent promotion, this man was a member of a small research team comprising three E.E.'s and a technician. His specific project entailed the creation of a transistorized electronic converter combining both digital and analog circuitry. "Research is really on the move at IBM," he says. "Personnel has increased ten-fold since 1950 and we expect to maintain this pace for some time."



Manufacturing Engineer: Also promoted recently, this man worked in one of IBM's many manufacturing plants. He was responsible for the analysis, design and procurement of equipment and facilities to produce the giant IBM electronic computers. "In a field as new as electronic computers," he'll tell you, "*unique* manufacturing equipment is often imperative. Creating this new equipment is a real challenge to an engineer's ingenuity."

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- Test equipment design

The electronic computer field offers one of the best ground-floor career opportunities today. Economic experts rank it with automation and nucleonics in growth potential. Sales at IBM, the recognized leader in this fast-growing field, have doubled, on the average, every five years since 1930. Engineering laboratory personnel has quintupled in the past five years. IBM's excellent salary and employee benefit program is instrumental in achieving an employee turnover rate far below the national average.

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CIRCLE 50 ON PAGE 48 FOR MORE INFORMATION

Titanium Bellows

Titanium bellows, used to allow for thermal expansion and contraction in aircraft ductwork, are made of special titanium alloys and weigh 44 percent less than stainless steel. They are produced in sizes ranging from 1 inch to 3½ inches ID, and are rated to operate at 50 to 400 psi. Construction is by special welding technique. Titeflex, Inc., Hendee St., Springfield 4, Mass.

CIRCLE 51 ON PAGE 48 FOR MORE INFORMATION

Resin Processed Coil

Processed with epoxy resin under vacuum and electronically cured, a new solenoid coil has a void free, high density casting. It is impervious to corrosive fumes and has high resistance to thermal shock and physical abuse. The unit is completely waterproof and carries an unconditional guarantee for limitless continuous service under rated conditions. Hays Mfg. Co., Dept 414-A, W. 12th St., Erie, Pa.

CIRCLE 52 ON PAGE 48 FOR MORE INFORMATION

Nonlinear Potentiometers

A new line of nonlinear, precision wirewound potentiometers in standard and sub-miniature sizes is available for Sine-Cosine and Square-Law functions. The devices incorporate design advances that assure highest resolution and close conformity for applications such as generation of functions, transmission of angular information, nulling in nonlinear systems and electro-mechanical data conversions. Standard Sine-Cosine Acepots come in sizes 30 and 20 with tolerances of $\pm 0.5\%$ peak to peak and $\pm 1.0\%$ peak to peak respectively. Standard Square-Law Acepots are in AIA sizes 30 and 20 with independent conformity tolerances of $\pm 0.25\%$ and $\pm 0.75\%$ respectively. Nonlinear Acepots meet military specifications. Ace Electronics Associates, Inc., 103 Dover St., Somerville 44, Mass.

CIRCLE 53 ON PAGE 48 FOR MORE INFORMATION

Encapsulated Networks

Epoxy resin inside a molded, non-porous phenolic case, is used to encapsulate a new line of resistor-capacitor networks. This construction offers high resistance to heat-humidity cycling such as that encountered in miniaturized circuits. The units have applications in coupling, pulse-forming and r-c filter networks. Resistor values of the devices range from 1000 ohms to 10 megohms and capacitor values from 100 to 10,000 micro-microfarads. Leakage resistance of the capacitors is greater than 10^9 megohm-micro-farads. Operating temperature range is 10 to 85°C. General Electric Co., Specialty Electronic Components Dept., Auburn, N.Y.

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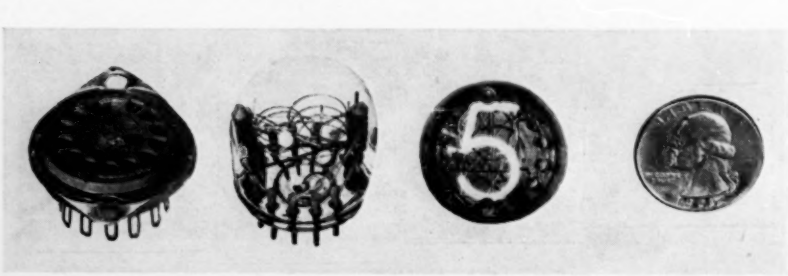

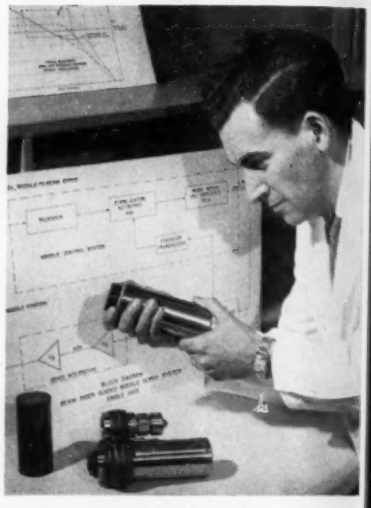

Devices For Outer Space

High precision missile devices propelled by the new "exotic" fuels will be developed by Sperry Gyroscope Co. in a new lab. now under construction. These new solid and liquid fuels hold great promise for tiny, self driven, instruments. Solid propellants are non-radioactive and basically stable, and may be safely machined and handled. If lighted with a match under room conditions they will burn like a cigarette; but fired in a suitably enclosed container, they instantly release enormous amounts of energy. A by-product of earlier research on guided missiles, propellants now being developed will give even greater range and speed. Sperry Gyroscope Co., Div. of Sperry Rand Corp., Great Neck, N.Y.

CIRCLE 55 ON PAGE 48 FOR MORE INFORMATION

Read-Out Tube

The first mass-produced read-out tube is now in production. This small, low cost device provides a wide viewing angle and sharply defined digit contours. The Nixie tube is inexpensive to install and maintain, using a minimum of power circuity, and components. It meets military requirements for shock, vibration and temperature, and is believed to be the simplest all-electronic method of performing the read-out function. Burroughs Corp., Detroit 32, Mich.

CIRCLE 56 ON PAGE 48 FOR MORE INFORMATION

New Radar Tube

Military secrecy has been lifted from an electron tube enabling radars to detect targets more clearly and at greater distances. Developed under the sponsorship of the Army Signal Corps Engineering Labs at Fort Monmouth, N.J., the new tube boosts the energy output of the basic signal 8 to 14 times. When added to existing air traffic controls, their effective range will be increased from 200 miles to about 350. The amplitron tube helps also to improve the radar's ability to distinguish fixed from moving targets, is valuable for use against enemy electronic jamming, and as a navigational aid. Its small size and light weight increase the ability of planes and missiles to reach their objectives. Though it requires less than half the voltage required for conventional tubes, it is twice as efficient as any present tube of comparable bandwidth, and has 10 times the bandwidth of any tube of comparable power. Raytheon Mfg. Co., Waltham, Mass.

CIRCLE 57 ON PAGE 48 FOR MORE INFORMATION

One-Microsecond Decade

A one-microsecond scaling circuit has been designed for use in nuclear scalers and regular counting equipment requiring extremely high speed and reliability. This is obtained by the use of a beam switching tube containing 10-stable beam positions. A single fast binary trigger is used to transfer the electron beam through each of the switching tube's 10 states. The decade readout is direct through ten-panel neon lamps. Two hot-cathode tubes are also employed—one, a premium type computer tube, the other, a Burroughs 6700. As the beam switching tube is stepped from 9 to 0, a negative output pulse is obtained which can be used to drive a mechanical register or another slower decade strip. Nuclear-Chicago Corp., 229 W. Erie St., Chicago 10, Ill.

CIRCLE 58 ON PAGE 48 FOR MORE INFORMATION

Magnetic Amplifiers

Long life magnetic amplifiers have been developed, containing no tubes or moving parts, with instant warm-up and power gain up to a million per stage. The units may be used in voltage and frequency regulators for a-c and d-c motors, and where d-c power supplies are used for computers, phototubes and testing devices. Consisting of a saturable reactor and rectifier, the amplifiers are shock and vibration resistant, have ratings ranging from microwatts to hundreds of watts and are practically maintenance free. American Electronics, Inc., 655 W. Washington Blvd., Los Angeles 15, Calif.

CIRCLE 59 ON PAGE 48 FOR MORE INFORMATION

P & B STRIKE SETTLED!

AN OPEN LETTER TO RELAY USERS

Potter & Brumfield, inc.

Dear Friends:

Ruthless violence, culminating on February 13 with the shooting of the four-month-old baby daughter of two of our employees, focused national attention on a recent strike at our Princeton, Indiana plant.

This unjustified strike was called on November 5, 1956 in the face of our "no strike" contract with Local 1459 of the International Association of Machinists. No demands or proposals for settling the strike were made by the Union. Two Company proposals were summarily rejected.

Settlement of the strike was reached on February 28, 1957.

Our plants in Laconia, New Hampshire and Franklin, Kentucky were not affected by the strike.

Production lines were shifted from Princeton to both Laconia and Franklin plants, and employment has been greatly increased at both locations. These plans were made before the work stoppage to increase production.

Production at Princeton was resumed on December 17th, and today a normal work force is manning the remaining lines. Until recently, the training of new workers restricted our productivity, but output now is at satisfactory levels.

With three plants to serve you, we pledge our continued efforts to provide you with relays of the finest quality. Our Engineering Department welcomes the opportunity to work with you on new designs and future projects.

Sincerely,

Dale V. Cropsey

Dale V. Cropsey
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CIRCLE 75 ON PAGE 48 FOR MORE INFORMATION

BOOKS

THE WORLD OF MATHEMATICS

By James R. Newman

Reviewed by Helen Hassler, General Electric Co.

It is with a feeling of interest and curiosity that one begins this four-volume set of essays and articles, and with a feeling of awe that one finishes it. It is a tremendous work—in scope, in sheer size, and in the taste shown in the selection of the writers represented.

Mr. Newman has done his mathematically-inclined readers a great service in presenting this book. He has selected representative works of a great many of the great mathematicians, scientists, and philosophers, from the time of A'h-mose to the present. The four volumes are subdivided into several categories: Volume I consists of selections on the general nature of mathematics, including some of the earliest mathematical and scientific treatises; a section of biographies of some great mathematicians and scientists; a discussion of the foundations of arithmetic and numbers; and a section dealing with the mathematics of space and motion.

Volume II presents the practical side of mathematics, consisting of three sections on "Mathematics and the Physical World", "Mathematics and Social Science", and "The Laws of Chance".

Volume III is concerned with the philosophical aspects of mathematics, containing, among others, a selection by Eddington on the theory of groups; Bertrand Russell and Hans Hahn on "The Mathematics of Infinity"; Peirce, Mach, and others on "The Mathematical Way of Thinking"; and selections on mathematics and logic, the vocabulary of mathematics, and mathematics as an art.

Volume IV contains essays on mathematical machines, a section entitled "Mathematics in Warfare", and an exceptionally fine collection of essays on the relation of mathematics to ethics and culture.

From the foregoing sketch of the contents of these books, it is evident why almost anyone with a scientific or mathematical turn of mind will find at least some sections to be of interest to him. The subjects dealt with cover such an immense area that one is hard put to choose a starting point. And this reviewer, at least, found it difficult to close the book once one was opened.

Under each subdivision are presented selections from the works of those who contributed substantially to the subject. Mr. Newman displays a fine sense of discrimination in the selection of these works. Nothing superfluous or trivial is presented, although several of the essays are lighter in vein than the usual scientific exposition. Most of them are directed toward the educated layman, having been originally presented as semi-popular lectures or articles. Some are of first importance in their field, such as Mendeleeff's "Periodic Law of the Chemical Elements" and Mendel's "Mathematics of Heredity". Others are the work of lesser-known authors, the "by-products" of more general inquiries. They are nonetheless interesting and informative, giving a breadth of scope to the books and an indication of the possible ramifications of any mathematical or scientific study.

Examples of these essays are "Mathematics of a Lady Tasting Tea" by Sir Ronald Fisher; J. B. S. Haldane's "On Being The Right Size"; and a section at the end of the last book of puzzles and riddles. They impart a feeling of the joy and beauty of mathematics, and leave one with an appreciation of the love which mathematicians bear toward their subject.

The amount of knowledge contained in these four books is breathtaking. The objection might be made that it is disconnected or too fragmentary to be of much value, but in this reviewer's opinion such an objection would betray a rather narrow outlook. If nothing else, each section is a "teaser"—one is eager to pursue the subject further. And there are ample references with which to do so. Every essay is meticulously footnoted and annotated—a further indication of the amount of labor that has gone into the compilation of these volumes.

To be sure, one could not gain a comprehensive knowledge of any of the subjects considered, on the basis of the selections included here. This is not the aim of the author—rather it is to give an idea of the immense scope of the application of mathematics to all fields, an idea of its history and development, and an appreciation of the work of those who have devoted their lives to mathematics and science. Mr. Newman has done more than an admirable job of fulfilling his aim—he also leaves one with an appreciation for his own considerable contribution.

The essays and articles themselves are, of course, the primary concern in the books. But this reviewer also found Mr. Newman's commentaries to be most interesting and informative. These commentaries appear before the selections of each author, and consist of a brief biography and a few interesting sidelights on the authors' lives and works. They are often humorous—not at all objectionable in such a lengthy work. They are written in a style which brings the "great" men back to the realm of human beings, and raises the lesser-known men to their rightful place in man's search for knowledge.

Many of the articles are difficult—this is not a work for those who are looking for an easy explanation of the universe. But for those who wish to enlarge their understanding of the development of mathematics, and for those who wish to understand the fascination of it, as well as for those who already have sampled its beauties, this is surely a monumental contribution.

Simon and Schuster, 630 Fifth Ave., N.Y.C. 2. 469 pp., $20.

PRODUCTION FORECASTING, PLANNING AND CONTROL,

By E. H. MacNiece.

John Wiley & Sons, 440 Fourth Ave., NYC 16. 363 pp + index, $8.25.

Primarily intended as a textbook for a one-semester course in production forecasting, planning, and control, this book may also be used by executives who wish to bring up to date their information about a field in which much progress has been made during recent years. —LS

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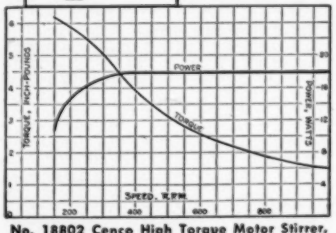

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HERE'S A BRIEF REVIEW OF LAST MONTH'S PRODUCT ADS FOR YOUR INFORMATION.

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These tubes memorize and process electronic data, so millionths of seconds stand still.
Radio Corp. of America, Harrison, N.J.

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This firm offers the most complete facilities for magnet production and research.
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Automatic Voltage Regulators **80**
These sensitive, rugged instruments keep input voltages precisely constant.
The Superior Electric Co.,
1803 Bradley Ave., Bristol, Conn.

What Is Lithium? **81**
It is many things for many uses, as shown in this firm's technical data bulletin.
Foote Mineral Co., 455 Eighteen West Chelten Bldg., Philadelphia 44, Pa.

High Temperature Insulation **82**
The problem of insulation at extreme temperatures is solved by these refractories.
Refractories Div., The Carborundum Co., Perth Amboy, New Jersey

Applications Aid **83**
This company's field engineers can help you get more out of your oscilloscope.
Tektronix, Inc., Box 831, Portland, Ore.

Speed Valves **84**
Fast tubing assemblies to 10,000 psi are easy with these valves and fittings.
Autoclave Engineers, 2934 22nd St., Erie, Pa.

Lithium Metal **85**
Diverse physical and chemical properties make lithium a valuable research tool.
Lithium Corp. of America, Inc.,
2697 Rand Tower, Minneapolis, Minn.

Hydroxylamine Salts **86**
These nitroparaffin derivatives have tremendous potential for experimentation.
Commercial Solvents Corp., Industrial Chemicals Div., 260 Madison Avenue, N.Y.C. 16

Precision Optics **87**
This firm offers the most advanced techniques in optical applications.
Texas Instruments, Inc., Optics Div.,
104 E. Foothill Blvd., Monrovia, Calif.

Pipe Heaters **88**
These electrothermal units give heat where you want it, when you want it.
Standard Scientific Supply Corp.,
808 Broadway, New York 3, N.Y.

Interference Microscope **89**
This instrument accurately measures minute depths of roughness on various surfaces.
Carl Zeiss, Inc., 485 5th Ave., N.Y.C. 17

Hydraulic Fluids **90**
This company can develop a new fluid to do exactly what your project may require.
Monsanto Chemical Co., Functional Fluids Dept RE 1, 800 N. 12th Blvd., St. Louis, Mo.

Transformer Designers **91**
This firm specializes in designing transformers to meet exacting conditions.
Altec Lansing Corp., 1515 South Manchester Ave., Anaheim, Calif.

Power Resistor **92**
This unit has drift-free stability and overload capacity needed in instrumentation.
Ward Leonard Electric Co.,
12 South St., Mt. Vernon, N.Y.

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Graphic Systems, 55 W. 42nd St., N.Y.C. 36

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These standard discs are available in four versions for different types of pick-ups.
W. & L. E. Gurley, 531 Fulton St., Troy, N.Y.

Pump Problems Solved **95**
This gasketless pump eliminates problems in handling corrosive and abrasive fluids.
Vanton Pump & Equip't Corp., Hillside, N.J.

Reagents Only **96**
This plant is designed exclusively for developing and manufacturing lab chemicals.
Fisher Scientific, 100 Fisher Bldg., Pittsburgh 19, Pennsylvania

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General Chemical Div., Allied Chemical & Dye Corp., 40 Rector St., N.Y.C. 6

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